

AUTOMATICITY AND HEMISPHERIC SPECIALIZATION IN EMOTIONAL  
EXPRESSION RECOGNITION: EXAMINED  
USING A MODIFIED STROOP TASK.

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The main focus of this investigation was to examine the automaticity of facial expression recognition through valence judgments in a modified photo-word Stroop paradigm. Positive and negative words were superimposed across male and female faces expressing positive (happy) and negative (angry, sad) emotions. Subjects categorized the valence of each stimulus. Gender biases in judgments of expressions (better recognition for male angry and female sad expressions) and the valence hypothesis of hemispheric advantages for emotions (left hemisphere: positive; right hemisphere: negative) were also examined. Four major findings emerged. First, the valence of expressions was processed automatically (robust interference effects). Second, male faces interfered with processing the valence of words. Third, no posers' gender biases were indicated. Finally, the emotionality of facial expressions and words was processed similarly by both hemispheres.

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## CHAPTER I

### INTRODUCTION

#### Overview

The main focus of this investigation was to examine the hypothesis that affective information, is processed automatically by using a modified photo-word Stroop task. In this modified Stroop paradigm, facial expressions were shown simultaneously with positive and negative words. The tasks were to categorize the valence of the expressions or words as positive or negative. Beyond the main focus of examining the automaticity of expression recognition, a number of additional hypotheses were examined: 1) The possibility that expressions are processed automatically along a continuum. Since negative expressions are more biologically significant, they should result in stronger automatic processing than positive expressions. This would be indicated by greater interference effects for negative than positive expressions. The two negative expressions that were used were anger and sadness. The positive expression was happiness. 2) The interaction of the gender of the poser (person expressing the emotion) with the gender of the subject was investigated to test the possibility that stereotypic display rules contribute toward the perception of better recognition of sadness in females and anger in males. 3) Finally, the valence hypothesis of emotions (left hemispheric advantage for positive emotions and right hemispheric advantage for negative emotions) was examined using this modified Stroop task in a visual field paradigm.

Various criteria that may define an automatic process are initially presented. A discussion on how expression recognition meets some criteria of an automatic process it that in is an innate, over-learned, and unconscious, and takes few attentional resources. Then various paradigms which are typically used to test automaticity, such as priming, visual search, brief stimulus presentation, and the Stroop task are examined. I then focus on the Stroop task and its various analogs. While discussing these various paradigms, empirical evidence is provided to support automatic processing of affective stimuli.

I also discuss studies that have examined expression recognition in general, as well as studies that have explored the interaction of subjects' and posers' gender. I briefly consider the valence hypothesis of emotions and studies that have investigated the hypothesis using visual field paradigms. Finally, the methods used by various researchers to achieve accurate photographic representations of facial expressions for stimuli are discussed. This area is important since I have developed my own photographic set of facial expressions for the experiments.

### Introduction to Automaticity

Several criteria may be met for a process to be considered automatic, such that it may be unintentional, involuntary, effortless, and autonomous, although not all are necessary conditions (Bargh, 1989; Logan, 1989; Shiffrin, 1988; Uleman, 1989). A process may be innately automatic, although it is more likely that a process became automatic through over-learning (Glass, Holyoak, & Santa, 1979; Lachman, Lachman, & Butterfield, 1979; Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). Repetition that occurs through over-learning strengthens memory representations so that the more

frequently they are activated, the stronger the representations become and the easier they are to activate in the future. Given the disagreement on the specific criteria that should be met to define an automatic process, I will use the definition of an automatic process as one that is over-learned, effortless, and unintentional.

Driving a car is an example of an over-learned process which becomes effortless and requires little attentional resources once mastered. For a skilled reader, reading is an example of an over-learned process that becomes automatic in the sense that it can occur unintentionally. This unintentional characteristic is consistent with the fact that cognitive processes can occur in parallel. In fact, the unintentionality of one process can cause a distraction and interfere with an unrelated process. This occurs despite the person's attempt to ignore the distracting process (Shiffrin and Dumias, 1981). The classic example of this is the Stroop effect, where the ability to name the color of words written in different colored inks is interfered with by the unavoidability of reading the words (Stroop, 1935).

As social creatures we encounter affective information every day, and we must make evaluations of such information. Facial expression recognition is an example of affective information that is a prime candidate for automatic processing because of its familiarity, and potential importance. In fact, recognizing facial expressions is considered by some to be an innate ability (Darwin 1872/1965; Izard, 1971). Others consider it to be a mixture of maturation and environmental learning. Regardless of whether it is innate or not, it is a highly over-learned process.

## Automaticity of expression recognition

### *Evolution of expressions*

Darwin believed that facial expressions were innate (1872/1965). In his book, *The Expression of Emotions in Man and Animal*, he discussed his belief that evolution had shaped human emotional facial expressions (1872/1965). He emphasized the importance of considering the expressions of animals to help us understand our human emotions.

Many biologists have looked to animals as a means of understanding the evolution of human expressions. For example, Van Hooff (1997) has studied primate facial behavior and social influences on the evolution of certain facial displays. From her studies she has concluded that it is possible to trace the human smile to a relaxed open-mouth display in many monkeys and apes. She considers this display to be an ancestral characteristic of primates. Such a cross-species connection of primate facial behaviors suggests that these displays have an innate basis.

Expressions have great communication value, and it is this value that has aided in their evolution. Andrew (1963) suggested that expressions were once a response to stimuli that have been shaped by natural selection, because of their importance in human communication. For example, the reflexive response to smelling a sour lemon has been labeled as disgust, and that same facial pattern is used in social situations to express that emotion. Communication that occurs through emotional expressions is crucial to the development and maintenance of healthy interpersonal relationships. Ekman (1999) has suggested that facial expressions are important for the formation of attachments and the regulation of relationships. Dimberg (1997) proposed that we are biologically

programmed to display distinct facial expressions, and from an evolutionary standpoint these expressions would have had little value if others could not decode and respond appropriately. The importance may be seen readily in aberrant relationships. For example, parents who are physically abusive have been reported to express more negative emotions than positive emotions (Bugental, Blue, & Lewis, 1990; Herrenkol, Herrenkol, Egolf, & Wu, 1991). Abused children and neglected children in turn, have been found to have more difficulty in discriminating expressions than normal children (Pollak, Cicchetti, Hornug, & Reed, 2000). In addition, children who are maltreated are also more likely to develop social and emotional problems (Rogosch, Cicchetti, & Aber, 1995). Neurological damage may negatively impact relationships by impairing people's ability to communicate emotions. It has been reported that people who have Mobius syndrome, a congenital facial paralysis, have greater difficulty in developing and maintaining casual relationships (Ekman, 1999). Stroke patients who have difficulty identifying the prosody that accompanies speech, or who cannot generate prosody that accompanies emotional utterances, have severe interpersonal difficulties (Ross, 1981).

Johnson-Laird and Oatley (1992) have suggested that the need to communicate universal experiences has been instrumental in the evolution of facial displays. For example, they consider achievement, loss, and frustration to be universal experiences. These are situations that have occurred since the beginning of man and resulted in the need to display emotions. This belief of reoccurring life experiences is shared by Tooby & Cosmides (1990) who suggest such common themes for emotion as "fighting, falling in love, and escaping predators" (p. 407-408).

An ability that is automatic would be expected to have survival value. Throughout life we experience situations that are common to all humans. Facial expressions allow essential communication of our emotions. This communication provides a foundation for the development and maintenance of relationships, which ensures the survival of our species.

### *Recognition across cultures*

Further support for innate and/or automatic expression recognition stems from the evidence that suggests expressions are universal. Darwin was the first to conduct cross-cultured study on facial expression recognition (1872/1965). He showed people of various nationalities photographs of facial expressions. He also requested facial descriptions of several emotions from men in various countries. After which he concluded, “The different races of man express their emotions and sensations with remarkable uniformity throughout the world” (1872/1965, p. 143).

Tomkins’ (1962) theory of emotion propelled Izard (1971) and Ekman and Friesen (1971) to independently study the universality of expression recognition. Tomkins’ theory was developed around the tenets that emotional facial expressions are universal and emphasized facial expressions as a key to understanding emotions (Tomkins, 1962). He suggested that the primary response to emotions occurs in facial expressions (Tomkins 1962, 1963). Further, he suggested that if emotions are consciously experienced, it is through feedback from the movements of the face. However, he also believed that the emotions could be experienced without outward displays.



Izard (1971) and Ekman and Friesen (1971) studied expression recognition using different photographs of expressions shown to various literate cultures. They found certain facial displays were common to all cultures for expressing basic emotions. This was true even though the researchers used slightly different terms for emotions. It is primarily from Ekman's and Izard's work that the widely held belief of a limited number of distinct primary emotions has developed.

Izard (1971) tested college age students from many cultures: American; English; German; Swedish; French; Swiss; Greek; Japanese; and African. A photograph of each expression was displayed for 15-20 seconds and the students had to choose from eight emotional terms: interest-excitement; enjoyment-joy; surprise-startle; distress-anguish; disgust-contempt; anger-rage; shame-humiliation; and fear-terror. The photos were of four different actors and actresses who had posed for each expression. The pictures chosen were those producing 70% agreement in a previous pilot study. He found that the majority of the cultures had high agreement (75% to 83%) on the recognition of the expressions.

Ekman (Ekman, Sorenson, & Friesen, 1969) chose the expressions for his studies by developing a new technique of measuring facial movements (Ekman, Friesen, & Tomkins, 1971). The photos were of actors who posed various expressions. The expressions were shown in 21 literate countries: Africa; Argentina; Brazil; Chile; China; England; Estonia; Ethiopia; France; Germany; Greece; Italy; Japan; Kirghizistan; Malaysia; Scotland; Sweden; Indonesia; Switzerland; Turkey; and the USA. Ekman and five other investigators ran the experiments independently. Subjects in each country saw

a photo and selected from six to ten emotional terms. Six expressions were consistently used as answers for all countries: happiness; anger; sadness; fear; disgust; and surprise. In 21 countries the “majority” of the subjects agreed on the expressions for happiness, sadness, and disgust. Anger had agreement of the majority in 18 out of 21 countries.

It is possible that the high degree of agreement among the six expressions was due to some bias of literate cultures. To test this possibility, Ekman and Friesen (1971) studied an isolated preliterate culture in New Guinea. Stories were read to the people in their native language who then chose a photograph which matched the story. They again found that the six basic expressions were highly recognizable. These findings of universality were strengthened by a replication in another isolated culture of West Iran (Ekman, 1972).

#### *Innate and Over-learned: Evidence from Infants and Children*

Additional evidence which suggests expression recognition is innate or at least an over-learned ability stems from empirical research on infants. It is well established that the ability to discriminate facial expressions begins in infancy, which suggests that this ability may be genetically based. Young infants are also sensitive to subtle changes in emotional expressions. Not only are three-month olds able to discriminate happy and sad faces from surprise, and happy from sad, but they can also distinguish among faces that vary in the intensity of a smile (Barrera & Maurer, 1981; Kuchuk, Vibbert, & Bornstein, 1986; Young-Browne, Rosenfield, & Horowitz, 1977). At four months, infants can discriminate a happy expression from angry or neutral expressions (LaBarbera, Izard, Nietze, & Parisi, 1976). By five months, they can discriminate among sad, fearful, and

angry expressions (Schwartz, Izard, & Ansul, 1985). Between five and seven months, infants can discriminate among happy, surprise, and sad expressions (Spiker, 1985). This ability to discriminate among different expressions is generalizable because infants are also able to make discriminations regardless of who makes the expressions. Seven month-olds can discriminate between happy and fear even when different people make the expressions (Nelson, Morse, & Leavitt 1979). The same age group can discriminate among happy faces and fearful faces when both male and female models pose the expressions (Nelson & Dolgin, 1983).

Children's ability to identify expressions also supports expression recognition as a well-learned ability. Gates (1923) reported one of the first studies investigating children's ability to recognize expressions. She used photographs of a female actress who had posed five expressions: joy, anger, pain, fear, and contempt. She found children as young as three could identify happiness. More recent studies have supported the conclusion that preschoolers can identify expressions (Reichenbach & Masters, 1983; Walden & Field, 1982). The ability to correctly identify expressions appears to improve with age until it equates the ability of adults. Michalson and Lewis (1985) found children improved from age three to age five. Izard (1971) found that by age nine, children's ability to recognize anger and enjoyment had reached ceiling levels.

#### *Innate and Over-learned: Evidence from Adults*

Adults are extremely accurate at identifying facial expressions, which further suggests that this ability is a highly over-learned process. Expression recognition studies typically examine either all or a subset of six basic expressions (happy, sad, angry,

disgust, fear and surprise). The three expressions of interest for the current studies are happy, sad, and angry. These emotions were chosen for the present study because they are the most frequently listed of the basic emotions (Fehr & Russell, 1984; Hunt & Hodge, 1971). The remaining studies reviewed contain adults as the subject population.

Kirouac and Dore (1982, 1984, 1985) have conducted a number of studies using Ekman and Freisen's (1976) stimulus set of expressions. Kirouac and Dore (1982) found happiness the most accurately recognized expression (97%), followed by anger (90%), and sadness (84%). They conducted a study where they examined the interaction of education, subjects' gender, and expression recognition (Kirouac & Dore, 1985), and found that female subjects were overall more accurate at identifying expressions, and this variable interacted with emotion and education level. However, the only post hoc analyses reported were on the expression variable; happiness (97%) was the most accurate, followed by anger (85%), and sadness (83%).

### *Gender Differences*

Additional studies that support the robustness of expression recognition have examined the possible interactions of the gender of the poser and the gender of the subject. It is difficult to make generalizations from these studies because of the differences amongst them in the expressions examined and type of dependent measures (e.g., accuracy, sensitivity, and intensity of expressions). Nevertheless, these findings warrant further investigation.

Stanners, Byrd, and Gabriel (1985) examined the possible interactions of the gender of the poser and the gender of the subject. They took photographs of college

students who were instructed to pose pleasant and unpleasant expressions. They selected those photos with a high agreement ( $> 90\%$ ) of recognition as pleasant or unpleasant. They found the female subjects (732 ms) were quicker to identify a female poser with a pleasant expression than male subjects (790 ms).

Rotter and Rotter (1988) used their own poser set. In a self-paced task, subjects looked at photos of emotional expressions (sad, angry, fear, disgust) and chose from a list of emotional terms. Overall, the female subjects (77%) were more accurate at identifying the expressions than the male subjects (73%). The sad expressions were recognized the most accurately (80%) and the angry expressions least accurately (64%). This is in contrast to Kirouac and Dore (1982, 1985) who used Ekman and Freisen's (1976) stimulus set and found the reverse. Rotter and Rotter (1988) also found male and female subjects were better at recognizing anger in male faces than in female faces. Although both genders were more accurate with male angry expressions than females', each gender was more accurate with their own gender. For example, male subjects had higher accuracy for the males' angry expressions than the female subjects and female subjects were more accurate at recognizing the females' angry faces than the male. Male and female subjects were both better at identifying a sad expression if a woman had made the face than if a man had made the expression.

Erwin et al. (1992) had subjects judge how happy, neutral, or sad each expression was on a seven-point scale. Subjects were shown an expression along with a neutral face. For the first experiment, the male subjects only saw expressions posed by males, and the females only saw expressions posed by females. The results did not indicate a difference

between the male and female subjects. However, it is unclear how to compare these results since each gender saw different posers. In a second experiment, to control for this confound, both male and female subjects judged pictures of male and female posers. They found that the male subjects were equally sensitive to male happy and sad faces. The female subjects were less sensitive to sadness expressed by males than happiness expressed by males. Both male and female subjects were less sensitive to sad expressions made by females. The effect seen for the female subjects may be a confound of their set of posers, in that their female posers may be truly less expressive because both male and female subjects responded the same way.

Plant, Hyde, Keltner, and Devine (2000) investigated gender stereotyping of emotions in a series of experiments. They had two women and two men pose anger, sadness, and two ambiguous blends of anger and sadness. The posers were trained in the display methods of Ekman and Friesen's (1976) Facial Action Coding System (FACS). This is a system of coded muscle movements of facial expressions. Subjects were shown the expressions and rated them on a seven-point scale for the intensity of each emotion. The results indicated that the male posers' angry expressions were rated as angrier than the female posers'. The female posers' angry expressions were rated sadder than the males'. In the ambiguous anger/sad blended expressions, men were rated as more angry and women sadder.

Overall, happiness seems to be the easiest expression to recognize (Kirouac & Dore, 1982, 1984, 1985). The accuracies of sadness and anger may be affected by the set of posers presented in the experiment (Kirouac & Dore, 1982; 1985; Rotter & Rotter,

1988). Stanners, Byrd, and Gabriel (1985) found females were quicker to identify a female pleasant expression than a male's expression. Erwin et al. (1992) found females were more sensitive to males' happy expressions than females' happy expressions. It may seem surprising that males in their study were equally sensitive to male happy and sad expressions, since happiness is almost always the easiest expression to recognize. However, most studies collapse either subject's gender or poser's gender, obscuring such an interaction. Rotter and Rotter's (1988) findings suggested both genders were more accurate at identifying angry expressions made by males and more accurate at recognizing sad faces expressed by females than males.

The perception of an expressed emotion may be influenced by the gender of the poser and the perceiver's interpretation could be driven by stereotypic beliefs. For instance, although men and women are thought to experience emotions similarly (Fabes & Maritn, 1991) the display of certain emotion may be perceived to be more frequent by one or the other gender. For example, Fabes and Martin (1991) found that subjects believed that women express sadness more frequently than men and men express anger more frequently than women. Such social display rules likely have their roots in evolutionarily adaptive behaviors and roles. It would have been adaptive for males to be able to display an expression such as anger that would cause fear and reduce the threat of attack. In turn, it may have been adaptive for females to look sad in order to elicit aid. The interpretation of ambiguous expressions seems to rely on stereotypical expectations that males are more likely to be angry than sad, and females are more likely to be sad than angry (Plant, Hyde, Keltner, & Devine, 2000).

### *Theoretical Accounts of Automaticity in Expression Recognition*

Ekman (1977; 1999) proposed two appraisal mechanisms for emotional stimuli, one automatic and the other an “extended” appraisal. He pointed to the speed of responses to emotional stimuli and unconscious activation of emotions as evidence of the automatic appraisal mechanism. However, he acknowledged that responses to emotional stimuli are not always rapid, but can be slow and conscious, thus an extended appraisal mechanism is needed to explain such delayed responses. Bargh (1989) suggested that people have preconscious information about the environment that is used to make judgements and decisions. This automatically available information needs “only the triggering proximal stimulus event” (p.11). He suggested that this triggering can occur “prior to or in the absence of any conscious awareness of that event” (Bargh, 1989, p.11). For LeDoux (1991) a “minimal stimulus representation” is needed to activate emotional processing. He suggested that such responses to innate stimuli are “hard-wired, species-typical behaviors” and such “reactions need to be executed with speed” (p. 50). According to Ohman (1983), an example of an innate stimulus that could initiate such a response would be a threatening or angry facial expression.

These various researchers believe that affective evaluations of stimuli can occur when a stimulus has been presented briefly. In addition, they suggested that few attentional resources are necessary to activate an evaluation. They also suggested that facial expressions are a category of affective stimulus that is likely to be processed in an automatic manner. There are numerous experimental paradigms that investigate the automaticity of a process. The next section provides empirical evidence of automatic



activation, evaluations of affective stimuli, and the different paradigms used in obtaining this evidence.

### Empirical Methods used to Investigate Automaticity

#### *Priming Studies*

Priming paradigms are one of several empirical paradigms used to examine automaticity. Priming occurs when a word (prime) is shown before a target word and the prime facilitates recognition of the target word. The effect of the prime is that it semantically activates a category which will aid in quicker processing of other semantically related words. Bargh and Pietromonaco (1982) demonstrated that personality trait words that were presented as masked primes and not consciously detected by the subjects influenced the rating of a hypothetical person. Other researchers have also found that impression formation and preference responses may be influenced by information or word priming that is not consciously detected by subjects (Bargh, 1989; Kihlstrom, 1987; Kitayama, 1990). Greenwald, Klinger, and Lui (1989) presented undetectable masked negative and positive primes. Subjects had to judge the valence of target words. They found that when the valence of the prime and target word were congruent (matched), the subjects' responses were quicker than if the valences for the two were incongruent

According to Pylyshyn (1984), negative affective stimuli can result in an attentional bias. Whereas many studies such as those discussed previously have shown automaticity of negative affective stimuli, it is unclear whether or not this automaticity aids in processing or instead captures attention and thus, requires additional attentional

resources. Matthews, Pitcaithly, and Mann (1995) used a lexical decision task to study the valence effect on priming of word pairs. Their study showed a stronger priming effect with negatively valenced word pairs than for neutral or positive words. Pratto and John (1991) used personality trait words (e.g. honest, sadistic) printed in color and found slower reaction times (RT) for undesirable terms than desirable terms. They explained this interference as occurring due to a psychological mechanism, “automatic vigilance”, which monitors the environment for possible danger.

#### *Brief Exposure Duration Studies*

A task that can be performed with few attentional resources is often referred to as an automatic process (Isen & Diamond, 1989). Julesz (1984) defines stimuli that are recognized at brief durations (160 ms or less) as items processed preattentively. The following studies empirically demonstrate that expression recognition can be performed with relatively high accuracy at very short exposure durations. Kirouac and Dore (1984) presented photos of two male and two female posers at various exposures ranging from 10 to 50 ms, with each stimulus followed by a masking pattern. Their study could be used to support preattentive recognition of expressions, since accuracy was high for 50 ms exposure durations (happy, 88%; sad, 80%; and angry, 80%).

Mandal and Palchoudhury (1985) have also examined the minimum exposure duration needed for expression recognition. They picked one poser from each of the basic emotions that had the “highest consensus” of agreement for each emotional expression in the Ekman and Friesen (1976) series. The exact posers, the gender of the posers, nor the number of test trials were revealed. The subjects were shown the six expressions at

various durations (1000 ms, 500 ms, and 250 ms), and chose the emotion from a list of six emotional terms. The overall accuracy decreased from 87% to 72% correct as the exposure duration decreased. As found by most studies, happiness (97%) was recognized the easiest collapsing across exposure duration. However, sadness (81%) was recognized more accurately than anger (65%). The subjects did not differ by gender in their overall ability to identify the expressions; however, women were better at recognizing sadness (96%) than men (65%), and men were better at recognizing anger (72%) than women (57%).

A more recent study of exposure duration and expression recognition was done by Ogawa and Suzuki (1999). They used only one of Ekman and Friesen's (1976) posers, poser JJ, for all six expressions. In a recognition phase, they initially present each expression for an unstated amount of time and the subject identified the expressions from the list of six basic emotions. Then the six expressions were shown at durations ranging from 4 ms to 64 ms, followed by a mask on each presentation. At 64 ms this poser's happy expression (96%) was the best recognized, followed by sad (89%), and then angry (74%).

These studies demonstrate that expression recognition is a process that can be performed well above chance even when exposed briefly. High accuracy at such short viewing presentations suggests that this process is highly over-learned and automatic. Happiness was again the easiest expression to recognize regardless of the poser. The recognition of sad and angry expressions seemed to be impaired at the shorter exposures, and was more dependent on the poser stimuli set.

### *Visual Search Paradigms*

Visual search paradigms are an additional method for examining the automaticity of a process. Such a paradigm typically present two different stimuli, and the task is to find one type of stimulus (e.g. a backwards arrow, ←) among a number of the other type of stimulus (e.g. forward arrows, →). If the time to search for the single stimulus among the distractors is not affected by an increase in the number of distractors, then the search is considered to be preattentive and automatic (Treisman, 1988). Hansen and Hansen (1994) have investigated the preattentive nature of angry faces using a modified version of Ekman and Friesen's (1976) expressions. They reduced the gray scale photos to black and white. This resulted in their stimuli resembling line drawings more than photographs. They created crowds of various numbers using either angry faces or happy faces with one face of a different expression included as a target. They found that angry expressions captured subjects' attention quicker than happy expressions. They also found that the subjects had longer delays of disengagement from angry faces than from happy faces.

Gilboa-Schechtman, Foa, and Amir (1999) conducted a study similar to Hansen and Hansen (1994) using Ekman and Friesen's photos, and constructed three types of crowd images: Angry; Happy; or Neutral. Subjects detected angry faces when in a crowd of happy expressions faster than when the condition was reversed. Mogg and Bradley (1999) have also used such a pop-out task. In their study when an angry face was among a crowd of happy faces, the subjects detected the lone angry face quicker compared to a happy face in a crowd of angry faces.

Using schematic happy and sad faces, White (1995) showed subjects crowds comprising either all the same expression or different expressions. Subjects were quicker at identifying the crowds as the same when all the expressions were happy compared to when all the expressions were sad. The additional time required to recognize a crowd of schematic sad expressions might be an example of the negative vigilance Pratto and John (1991) attributed to the grabbing and holding of attention so that it becomes difficult to disengage from negative stimuli.

The visual search paradigms that used photographs of expressions demonstrated that angry expressions are more preattentive or automatic than happy expressions. This seems in contrast with the other studies that support happiness as the easiest expression to identify. However, Purcell, Stewart, and Skov (1996) have suggested that in a social situation such as a crowd, it would be evolutionarily beneficial to be able to detect an impending attack. So the sociobiological context of a recognition task may affect which expression is recognized the quickest. White's (1995) schematic expression study resulted in longer RT responses to sad expressions than a happy expressions. This may have occurred because the stimuli had lines as facial features. These lines may have disturbed processing compared to what may occurs with more ecological stimuli, photographic images of expressions.

## Stroop Task

### *Introduction to the Stroop effect*

The task (and variations of the task) developed by John Ridley Stroop in 1935 has become one of the more prolifically used experimental paradigms in the study of

automaticity in cognitive processing (Logan, 1980; MacLeod, 1991). The reason for this is its robust and intriguing interference effect. A discovery by Cattell (1886), that reading words out-loud could be done quicker than naming objects, formed a springboard which led to the combination of words and colors by Stroop. Stroop was interested in the effects such compound stimuli would have on each dimension of the stimuli. For example, how would the ink color affect reading the word, and how would the words affect naming the ink colors. He used five ink colors and corresponding words. In one experiment, he had the color words printed in all five colors and the participants read aloud the word (target) and ignored the color of the ink (distractor). For his control condition all the words were written in black ink. There were no significant differences between the experimental and control conditions. In his second experiment, the words were again written in the five colors, but the control condition was colored ink squares. The participants were to name the ink color aloud. He found that the participants' reaction time for naming the color strips was faster than reading the colored words. By subtracting the mean reaction time of the control condition from that of the experimental condition, he found an average positive 47ms delay or interference for the incongruent words and ink colors. Thus, the word presented interfered with the naming of the colors. The interference the words caused is referred to as the Stroop effect. If the result had been a negative value, then a facilitation effect would have been observed.

#### *Models explaining the Stroop interference*

Stroop interference is thought to occur because attention is divided between the two processes of word reading and color naming, and one (word reading) causes

interference in the other (color naming). Several models attempt to explain the interference by focusing on the possible stage of processing where the interference occurs. Although an early stage model has been proposed, it is more widely believed that a later stage effect is more probable.

An early stage explanation states that the interference occurs in the initial perceptual encoding of the two stimulus dimensions. Hock and Egeth (1970) suggested that the word draws attention away from the target (ink color) which decreases the amount of processing available for encoding the color. However, semantic interactions (interference caused by incongruent pairing of a word and picture when either must be categorized) seen in picture-word Stroop analog tasks are difficult to reconcile with this model. As Glaser and Dungelhoff (1984) point out “semantic interaction of two signals seems impossible before they are semantically evaluated” (p. 641).

Another hypothesis, Response Competition, states that the interference occurs at a later response stage. Here the responses have been selected and the delay in naming the color is a result of competition between the two stimuli (color word and ink color) to produce a response. There are two possible explanations for the delay of the target response. One is the relative speed-of-processing hypothesis and the other is the automaticity of word reading.

The relative speed-of-processing hypothesis had been thought to account for the interference effect. This explanation is analogous to a horse race. The two potential responses (word reading and color naming) compete to be the emitted response. When the distractor produces the faster process (word reading), it must be inhibited to allow the

slower response (color naming) to be selected. This being the case, if the slower stimulus was given a head start, the interference should decrease. However, studies that manipulated the time delay between target and distractor by varying the stimulus onset asynchrony (SOA) failed to reduce Stroop interference (Glaser & Glaser, 1989). Results from other studies also support the rejection of this model (Dunbar & MacLeod, 1984; Glaser & Dungelhoff, 1984; Glaser & Glaser, 1982).

The other possible explanation of the interference effect lies in the automaticity theory, which suggests more attention is required for one of the stimuli than for the other. Therefore, naming an ink color requires more attentional resources than reading a word. This imbalance is thought to occur because reading words is such an over-learned process and therefore, requires little attention (Logan, 1980; MacLeod, 1991; Posner & Synder, 1975; Shiffrin & Schneider, 1977).

It is probable that automaticity works on a continuum as opposed to an all-or-none model (MacLeod & Dunbar, 1988; Logan 1985; Shiffrin, 1988). A continuum would allow for a range and combination of possible interference outcomes. MacLeod (1991) explains the possibilities as follows: stimulus A may only interfere with the stimulus B, A and B may interfere equally, or B may only interfere with A. This allowance of a continuum addresses the reverse Stroop effect when both stimuli interfere with one another (MacLeod, 1991). For example, if both word reading and expression recognition were automatic processes, then each process could potentially interfere with the other. However, one process might be more over-learned and automatic than another, and result in asymmetric interference effects.



### *Variations of the Stroop task*

Although the classical Stroop experiment had the two stimulus dimensions physically integrated, many variations of the task spatially separate the ink colors and words by using color patches and achromatic words (Dyer, 1971; Dyer & Severance, 1973). Nonintegrated Stroop stimuli can show interference and facilitation (Dyer, 1973; Gatti & Egeth, 1978; Glaser & Glaser, 1982; Kahneman & Chajczyk, 1983). However, Stroop interference decreases with increased physical separation between the two stimuli (Glaser & Glaser, 1989; MacLeod, 1991).

### *Emotional Stroop Task*

Matthews and Wells (1999) suggested attention and emotion are closely linked because states of emotion influence performance on cognitive tasks as demonstrated from the numerous studies on the impairment of cognition due to depression and anxiety (Eysenck, 1992; Harlage, Alloy, Vazquez, & Dykman, 1993). They proposed that negative emotions have two effects; impairment (decreased performance), or attention bias (prioritized processing).

A modified version of the Stroop task called the emotional Stroop task has been used to test the possible attentional bias of negative affective stimuli (Dawkins & Furnham, 1989; Mogg & Bradley, 1999; Moggs, Mathews, & Weinman, 1989). The emotional Stroop task uses the same basic paradigm with the presentation of words in black and colored ink, except the words are positive, negative, or neutral. Such studies have found subjects who were anxious or depressed usually have a bias in the form of more interference for negatively valenced words. For example, anxious patients need

more time to name the color of threatening words than neutral words (Moggs, Mathews, & Weinman, 1989). Also, attentional bias has been seen with the use of subliminal stimuli in the emotional Stroop task (Mogg & Bradley, 1999).

Bradley, Mogg and colleagues (Bradley et al. 2000) have used “threat” or angry, neutral, and happy expressions to conduct a series of experiments on the preattentive nature of anxiety. Although their focus was on anxiety, they have demonstrated that angry expressions were processed preattentively or automatically by non-anxious subjects. They used a modified probe task where a pair of expressions (neutral, happy or angry) were presented simultaneously. Directly following the offset of the expressions was a brief presentation of a dot. The subjects then responded as quickly as possible to the location of the dot probe. They found normal subjects were slower to respond in the presence of the angry face than subjects with higher levels of depression and anxiety (Bradley, et al., 2000). In another study they used the same paradigm, but presented the pairs of faces for 14 ms, followed by masks. They found subjects were faster to detect probes when they were presented in the same location as the threat expressions and when presented in the left visual field. (Mogg & Bradley, 1998). This left visual field/ right hemispheric advantage for anger has been reported by other researchers (Christianson, Saisa, & Silfvenius, 1995).

#### *Picture-word analog task*

One analog of the Stroop task is the picture-word task. This paradigm uses words and line drawings as the two stimulus dimensions. Hentschel (1973) was the first to employ this Stroop analog task by embedding words in line drawings. The subjects

named the pictures and read the words. This variation has shown the classical Stroop interference, where the word reading process interferes with naming the pictures. Rosinski, Golinkoff, and Kukish (1975) showed that incongruent words printed inside a picture interfered with naming the pictures. However, when reading the words, the pictures had only a weak interference effect. In a later study, Rosinski (1977) demonstrated that words of the same category as the picture had more of an effect than words of a different category. For example, the picture of a MOUSE with the word *dog* printed inside resulted in more interference than when the MOUSE picture had *car* printed inside it. The control conditions were either rows of Xs or pictures alone. Facilitation was also found. Words of the same category as the picture (congruent words) resulted in a reduction of response times compared to naming pictures without the words added (Posnansky & Rayner, 1977; Rayner & Posnansky, 1978; Underwood, 1976).

The picture-word variation of the Stroop task is important because I further modify this paradigm by using a photo-word combination as my Stroop stimulus. The fact that interference and facilitation can be seen in the picture-word Stroop analog suggests that it may also be found in a photo-word variation. The following series of studies suggest that if the task is changed to categorization as opposed to reading and naming, then the picture may produce interference in categorizing the word. In addition, the following studies demonstrate the use of affective stimuli in picture-word paradigms. The last study I discuss in this section is one that has used photo-word combinations as stimuli.

Another variation of the picture-word paradigm employs a categorization task instead of reading and naming the words and pictures. With the naming and reading tasks, the pictures produce little interference on word reading. However, when the word is instead categorized, an interference occurs when a picture is from another category (Glaser & Dungelhoff, 1984; Smith & Magee, 1980). Smith and Magee (1980) had subjects name or categorize words and pictures. For example, a picture of a GLOVE might have the word *mouse* printed inside. They found that when the words had to be categorized (in this case the response should be “clothing”) and the word and picture were incongruent, categorization was slowed and the pictures caused an interference effect. Glaser and Dungelhoff (1984) found similar results. For the control conditions, rows of Xs and drawings of boxes were used.

*Stroop picture-word analog with affective stimuli*

De Houwer and Hermans (1994) investigated the affective processing of words and pictures using a picture-word paradigm. They used line drawings of positive (e.g., rabbit) and negative (e.g., snake) animals. The control for the word target was a rectangle and a row of Xs when the target was a picture. In the first experiment, subjects saw a picture of a SNAKE with the word *rabbit* printed inside. When the target was the picture, subjects categorized the animal as positive or negative. When the word was the target, subjects categorized the word as positive or negative. Interference was observed in the *Word* task, incongruent pictures slowed the response of labeling a word as positive or negative. In addition, negative targets (both words and pictures) were responded to slower than positive targets. Their second experiment was similar to their first except that

in the *Word* task, subjects read the word. When the target was the picture, subjects named the picture. Interference was seen in both the *Picture* and *Word* tasks for incongruent conditions where the word and picture affect did not match.

#### *Stroop analog task with expressions*

Stenberg, Wiking, and Dahl (1998) used a Stroop-like task to investigate what they refer to as the “Positive Valence Advantage (PVA)” of words. They hypothesized that positive words have an advantage of being responded to quicker than negative words because negative words hold attention. They were particularly interested in how this advantage could be modified when facial expressions were paired with the words. They hypothesized that by pairing happy expressions with positive words, the PVA would be enhanced compared to a condition using neutral expressions. They further hypothesized that when sad or angry expressions were paired with positive words, the PVA would reverse.

They used five angry and five happy expressions from Ekman and Friesen’s (1976) stimulus set. Three neutral expressions were also shown. One hundred and twenty words were chosen based on their ranking on a pleasant-unpleasant dimension. The stimuli in their studies were faces with words placed across the noses. The words were printed inside a gray rectangle. In the first experiment, each face was presented alone for 250 ms, then the words were superimposed across the nose and the pair was displayed for another 1500 ms. Subjects classified the words as positive or negative and had to ignore the pictures. When considering the expressions as a group, the RTs indicated that the happy and neutral faces were recognized faster than the angry expressions. They also

found that the congruent condition, where the happy expressions were paired with positive words, resulted in quicker responses than when positive words were paired with neutral expressions. However, the angry expressions also resulted in quicker responses to the positive words compared to the neutral expressions.

In a second experiment, Stenberg et. al used six happy and six sad expressions from Ekman and Friesen's (1976) set with 200 different positive and negative words. The control condition was a "pseudo-face" instead of a neutral expression. The pseudo-face was a blurred face. In this experiment, the word-expression pair was displayed simultaneously for 750 ms. They found that the RTs for the pairing of the positive words and happy expressions were faster than the incongruent condition of happy expressions and negative words. The congruent condition was also faster than the incongruent condition for the sad expressions. This result was contrary to their hypothesis that the positive words regardless of the expression would result in faster processing.

In their third experiment, they used sad, angry, disgusted, happy and neutral expressions along with a new set of positive and negative words. The expressions were displayed for 300 ms before the word was superimposed. The pairs were then displayed together for 500 ms. The task was the same as before; the subjects judged if the words were positive or negative. The happy expressions increased the PVA compared to the neutral expressions, so the difference between the congruent condition with happy expressions and positive words and the incongruent condition was greater (54 ms) than the difference between the congruent and incongruent condition of the neutral expressions. For all of the negative expressions, the incongruent conditions of positive

word and negative expression were responded to faster than the congruent conditions. This was in agreement with their hypothesis that negative words would be processed slower than positive words regardless of the expression they were paired.

Stenberg et al. (1998) used a photo-word Stroop analog task with expressions. They also used a valence categorization task. In experiment 2, they demonstrated that positive words paired with happy expressions were responded to faster than negative words paired with happy expressions. They also found a similar pattern with the sad expression, where the congruent condition was responded to faster than the incongruent condition. Although I used a similar photo-word paradigm as Stenberg et al., there were numerous differences. 1) They only considered a word categorization task. 2) They used black and white photos. 3) They used all types of positive and negative words. 4) They used neutral expressions as controls.

#### Stroop Analog Task: Central Presentation

Thus far, I have provided empirical evidence suggesting expression recognition is an automatic process. I also discussed various experimental paradigms that are used to investigate automatic processes, focusing on the interference effect seen in modified Stroop tasks. Clearly, these studies demonstrate word reading is an automatic task. The categorization of words has also been suggested to be an automatic process. In my modified Stroop task I used a photo-word combination. Positive and negative words were superimposed across faces that expressed positive (happy) and negative (angry or sad) emotions. The tasks were a valence categorization of the expressions and words (as positive or negative). Given that both tasks are automatic, the continuum theory of

automaticity would suggest that one task could be more automatic than the other. I hypothesized that the expressions would interfere with the word categorization process more robustly because of the biological significance of emotional faces. In addition, I expect the negative expressions would cause more interference than the positive expressions. Furthermore, I predicted that the gender of the poser and the gender of the subject would not interact. Specifically, I anticipated that when considering the expressions, both male and female subjects would be more accurate and faster at recognizing an anger face when posed by a male. In addition, subjects would be better and faster at recognizing a sad face expressed by a female.

#### Stroop Analog Task: Lateral Presentation

I used the results from my automaticity studies as a base to help guide my last two experiments where I investigated the valence-based hypothesis of emotional processing. There are two theories on the hemispheric specialization of emotional processing. The right hemisphere hypothesis proposes a right hemisphere advantage in processing all emotional expressions. The opposing hypothesis and the one of interest here is the valence-based hypothesis. It suggests the right hemisphere is superior in processing negative emotional information and the left is superior in processing positive emotions.

#### *Hemispheric Specialization Hypotheses*

The valence hypothesis arose from observations that unilateral brain damage to the left hemisphere (LH) resulted in catastrophic reactions (tears, despair, anger) although damage to the right hemisphere (RH) often produced an indifferent reaction (indiscriminate euphoria, lack of concern) (Gainotti, 1972; Goldstein, 1952). Similar



observations were seen when unilateral hemispheric sedation with amobarbital sodium was used for the assessment of language dominance (Terzian, 1964; Rosski & Rosadini, 1967). A number of visual-half field studies with normal individuals have lead to empirical evidence in support of the valence hypothesis (Bryson, McLaren, Wadden & MacLean, 1991; Burton & Levy, 1989; Jansari, Tranel, & Adolphs, 2000; Reuter-Lorenz & Davidson, 1981)

*Empirical evidence for Valence Hypothesis.*

Ley and Bryden (1979) were among the first to examine hemispheric specialization in the context of emotional facial expressions. However, their facial expressions consisted of cartoon line drawings of five male faces. The five facial expressions ranged from extremely positive to extremely negative. Whereas Ley and Bryden did not classify the facial expressions into emotional categories such as sad or happy, the extremely positive face could be called happy and the extremely negative face could be called angry (see figures in Ley and Bryden, 1979). The subjects were shown a target and then a comparison face (both lateralized to the same hemisphere), and were to judge if the two faces were of the same or different emotions. The left visual field/ right hemisphere (LVF/RH) was superior for the extremely positive and extremely negative emotional expressions. In addition, the LVF/RH was better in judging the emotions accurately.

Reuter-Loenz and Davidson (1981) conducted a study using happy, sad, and neutral facial expressions from Ekman and Friesen's (1976) set. They presented two emotional expressions simultaneously, but only one to each hemisphere. One of the

expressions was always neutral and the other was either happy or sad. The subjects were to indicate in which visual field the happy or sad expression appeared. They found reaction times were faster when the happy expressions were shown in the right visual field (RVF), whereas the sad expressions were responded to marginally quicker when shown in the left visual field.

Bryson, McLaren, Wadden and MacLean (1991) were concerned that the hemispheric differences found by Reuter-Lorenz and Davidson (1981) might be due to lateral asymmetry in the facial expressions they used. Bryson et al. (1985) used the same stimuli, but added a mirror-image condition which did not produce any interesting results. In the normal condition, they found results similar to Reuter-Lorenz and Davidson in that responses were faster to closed mouth happy faces in the RVF/LH and marginally faster to sad faces in the LVF/RH. They distinguish between open and closed expressions, because some of Ekman and Friesen's (1976) expressions are with open mouths. These open mouths may provide additional perceptual cues (e.g., teeth) that the other expressions are lacking.

Strauss and Moscovitch (1981) presented two of three possible expressions: happiness, sadness, or surprise simultaneously in the same visual field. The expressions were from Ekman and Friesen's (1976) series. The subjects either responded to the sameness of the poser (same person in both pictures) or the emotional expressions of the faces. They found a gender effect in that female subjects responded faster when the expressions were presented to the LVF/RH.

I examined the valence hypothesis using my compound expression/word stimuli. I presented the stimuli randomly to either visual field. The subjects performed two separate tasks. They responded to the affective valence of the words by categorizing them as positive or negative. In a separate task they responded to the affective valence of the expressions and categorized them as positive or negative. In the *Word* task, I expected the RVF/LH to show an overall advantage, since language is predominately processed by the LH (Peters, 1995). An interaction of visual field and affective valence of the words should result with a left hemispheric advantage for the positive words and a right hemispheric advantage for the negative words. In the *Expression* task, I expected the LVF/RH to show an overall advantage, since faces are predominately processed by the RH (for reviews, see Bruyer, 1986; Rhodes, 1985). I also expected the LVF/RH to demonstrate an advantage in processing the negative expressions. The RVF/LH should have exhibited an advantage in processing positive expressions.

#### Stimulus Sets of Expression Recognition Research

##### *Ekman and Friesen's (1976) Stimulus Set.*

The most common way of studying facial expression recognition is using a task where photos of various expressions are shown and the subjects pick the emotion expressed from a list of emotional terms. The photos or slides used in most expression recognition tasks since the 1970s are those developed by Ekman and Friesen (1976) called Pictures of Facial Affect. The stimuli were selected based on the results of the following testing. Black and white slides were shown to small groups of approximately equal numbers of male and female U. S. college students for ten seconds each. The exact

number of subjects was not reported. The subjects chose the expression displayed in each slide from a choice of six emotional terms: happy, sad, angry, fear, surprise, and disgust. There were six male and eight female posers for the expressions of happiness and sadness. Five males and six females posed the angry expressions. The posers were trained to activate and relax certain muscles according to Ekman and Freisen's (1976) FACS.

Although these slides and photographs of expressions are the most commonly used stimuli in expression recognition studies, there are drawbacks to these photos. First, although the posers were instructed which muscles to use to produce each expression, there are variations in the expressions. Some pictures of the same expressions have either an open or closed mouth. Second, there are variable results with respect to the degree of agreement for each emotion. The accuracies for the happy expressions are relatively consistent, falling mainly in the upper 90s to 100%. However, the accuracies for the different exemplars of the sad and angry expressions are much more variable. They range from 74% to 100%. Third, such cues as earrings, clothing styles, and openness of the mouths were not controlled in the photos. These differences may provide unwanted perceptual cues which may confound the expression recognition tasks. Fourth, and perhaps most importantly, the ecological validity of these photos is somewhat questionable since they are in black and white. Finally, the photos are almost thirty years old, so the hairstyles and clothing appear dated.

*Additional Expression Stimulus Sets.*

Other researchers have developed their own facial expression sets. Bradley, Mogg, Millar, and Neil (2000) have developed a set of stimuli they used in their studies of anxiety-related attention bias. From a pool of pictures where various people posed angry, sad, happy, and neutral expressions, they had four judges rate each expression on a six-point scale. The criteria for selection of the photos to use in their studies were that the expressions had to rank higher than 3.75 on the correct emotion and score no more than 2.00 for the other expressions. These photos are black and white.

Erwin et al. (1992) constructed their own set of facial expressions (Erwin et al. 1992). They had actors and actresses pose happy, sad, and neutral expressions. The best of these black and white photos were shown to 160 male and female college students. Each photo was displayed for seven seconds while the subjects classified the expressions as one of nine choices: happy; sad; angry; scared; enthusiastic; sleepy; surprised; neutral; and none of the expressions suggested. The answers were tabulated with enthusiastic pooled as a happy and any choice besides happy, sad, and neutral pooled into another category. Those photos judged correctly at least 70% of the time were used in their studies of facial discrimination tasks.

Rotter and Rotter (1988) took color pictures of male and females posing sadness, anger, fear, and disgust. Ten judges then separated the photos into piles for each of four expressions or an uncertain pile. Those photos with the highest percentage correct (percentages were not given) were used in their studies.

### *Development of a Facial Expression Stimulus Set*

Over the past four years I have been building an expression stimulus set. I have taken photographs of 15 males and 27 females. The posers have been undergraduates, graduate students, and staff members of the University of North Texas. Although I did not record the ages of the posers, the original set of volunteers range from 20 to 60 years of age, with the majority in their 20s and 30s. The posers have been volunteers who were asked to express three emotions: happiness, sadness, and anger. Multiple pictures were taken for each poser for each expression. The majority of the pictures were taken in the same room with similar lighting.

The first series of photographs were taken in 1996 and 1997. Seven males and seven females posers were photographed. The posers deemed by four judges to best express the three emotions were selected. This resulted in the selection of two male and two female posers, each expressing all three emotions. Various different photos of their best photographic expressions of the three emotions were shown in a reliability study (*Stroop Analog Task: Words and Faces* reliability study). These slides were shown to 39 undergraduate (28 females) students of the University of North Texas. The slides were shown for 10 seconds each. The subjects chose from a list of three emotions: happy, sad, and anger. Twelve slides of the four posers resulted in accuracies at ceiling level (see Table 1).

To increase the number of posers in the series, Experiment 1 (Accuracy Study of a Facial Expression Stimulus Set) was conducted. The photographs of posers not previously chosen for the *Stroop Analog Task: Words and Faces* reliability study were

shown in Experiment 1. Additional photographs were also taken of different posers. From a set of 21 male and female posers, pictures of the best expressions were chosen by six male and female judges. For the final set of pictures selected, all posers were in their 20s and 30s. The stimulus set of Experiment 1 has numerous advantages over other expression stimulus sets: 1) The photographs are in color; 2) Most of the photographs were taken recently, so their hairstyles are current; 3) They are closer in age to the subjects' ages than Ekman and Friesen's (1979) set; 4) They have been tested at an exposure duration close to that of Experiments 2, 3, 4, and 5; and 5) There were an equal number of male and female judges. Although I conducted two tasks (*Identification* and *Rating*) in Experiment 1, I was only interested in the Identification task in selecting stimuli for the other experiments.

## CHAPTER II

### METHOD

#### Experiment 1: Accuracy Study of a Facial Expression Stimulus Set

##### *Participants*

The participants were 20 male and 20 female undergraduate students of the University of North Texas. All subjects had normal or corrected to normal vision. They received extra credit course points for their participation in the study. Their ages ranged from 18-26.

##### *Stimuli*

##### *Facial Expressions.*

Colored slides were taken of 14 male and 22 female Caucasians posing three facial expressions (happy, sad, and angry). The posers were Psychology Graduate students, Drama Major students, and staff members of the Psychology Department of the University of North Texas. The posers lacked any overtly distinguishing characteristics (i.e., earrings, glasses). Slides and photographs that were deemed good representations of the desired expressed emotions by eight judges were selected and used as stimuli in the experiment.



## *Procedure*

### *Presentation.*

The slides were presented in a pseudo random order using a Kodak Ektagraphic III projector and pictures were displayed using Microsoft's PowerPoint and a digital projector. The experiment consisted of two tasks (*Identification* and *Rating*) which were conducted in several group settings. The slides, including two practice slides, were presented in different orders for the two tasks. An answer sheet was given to each participant before each task along with verbal and written instructions. The answer sheets were collected immediately following the completion of each task.

In the *Identification* task the subjects were told that slides of various people expressing happiness, sadness, and anger would be shown for one second each. They then had four seconds to select which of the three emotions they believed the person had been expressing. They were to circle an emotion, and once they made a choice they were not to change the answer. They were also asked to identify the expression for each slide independently, and not compare it to any other slide.

For the *Rating* Task, they were told to rate each slide on the intensity of each expression for all three emotions on a seven-point scale by circling the appropriate number. A zero indicated no expression of the emotion and a six represented the most intense expression. It was stressed that each slide should have three ratings for how happy, sad, and angry the expression was. Each slide was shown for 10 seconds for this condition.

## Experiments 2 & 3: Central Stroop Task: Expressions and Words

### *Participants*

The participants were 64 undergraduate students of the University of North Texas. There were equal numbers of males (16) and females (16) participating in each of the two experiments. Ages ranged from 18- 41 years old. All the participants spoke English as their native language and had normal or corrected to normal vision. The participants were right-handed as determined by the Edinburgh Handedness Inventory, please see Appendix A (Oldfield, 1971). For their participation in the study, they received extra credit course points.

### *Stimuli*

The Stroop stimuli consisted of a facial expression with a word superimposed across the nose. The expression and the word matched in that both represent a positive emotion (happiness) or both represent a negative emotion (anger or sadness). Thus, the expression and word were congruent in their emotional valence. Alternatively, the expression and the word were incongruent in their emotional valence, where one represented a positive emotion (happiness) and the other represented a negative emotion (anger or sadness).

### *Facial Expressions.*

Eight digitized colored photographs of four males and four females were used for each emotion. For example, for the happy expression there were four male and four female posers. The photographs were selected based on the results of the *Identification* task of Experiment 1, Accuracy Study of a Facial Expression Stimulus Set (see table 2).

Each poser chosen expressed at least two of the three emotions, happiness and either anger and/or sadness. The digitized photos were cropped to fit a fixed-sized rectangular frame (6 cm width x 8 cm height) so that only the poser's face and a small area around the face was visible. The participants sat 114 cm away from the computer screen. Thus, the face subtended a visual angle of 3 ° horizontally and 4° vertically. Any obviously distinguishing characteristics of the individual photos (e.g. distracting hair strands, odd coloration) were removed using Adobe Photoshop©. The final product was a rectangular matted digitized color photo which included a face, hair and shoulders with a word superimposed across the nose (see Appendix B for examples). The Stroop stimuli were presented against a gray background.

#### *Words.*

Eighteen words were chosen from a larger number of words that various corpora had identified as fitting into one of the basic emotional categorizes of happiness, anger, or sadness, see Appendix C (Clore, Ortony, & Foss, 1987; Fehr & Russell, 1984; Johnson-Laird & Oatley, 1989, Tiller, 1988). The words *happy*, *angry*, and *sad* were chosen because they represent the exemplars of their respective emotional categorizes. The remaining 15 words were selected based on their exemplar status, word frequency (less than 10 per million) and length (less than 8 characters) (Carroll, Davies, & Richman, 1971). The font style of the words was bold 16-point Times New Roman. The words were printed in lower case in black centered on the lower part of the nose on each face. The words ranged from 2.5 cm to 3 cm horizontally and 0.5 to 1 cm vertically. They were

presented horizontally. They subtended 1.25 degrees of visual angle horizontally and 0.5 degrees vertically.

### *Apparatus*

A Pentium III computer with an 18" VGA color monitor was used to display the stimuli. The stimulus presentation and data collection were done by the program, InstEP, with a two-button computer mouse used to make responses.

### *Procedure*

#### *Presentation.*

Subjects were run in either the *Happy and Angry* Experiment or the *Happy and Sad* Experiment. The difference between the two experiments was in the negative emotion presented for the expressions and words; happy and angry or happy and sad. Each experiment comprised two tasks completed in random order by each subject: *Expression* and *Word*. In the *Expression* task, the subjects responded as to whether the facial expression was positive or negative, by pressing the corresponding mouse button. In the *Word* task, they judged whether the word was positive or negative, again by pressing the corresponding button on a mouse. The *Word* task comprised 132 trials. The *Expression* task comprised 144 trials. The difference in the total number of trials results from the different number of control trials for each task. There were 24 congruent and 24 incongruent trials for each of the two emotions. For example, in the HAPPY congruent condition, 24 happy facial expressions were paired with the positive words. For the HAPPY incongruent condition, 24 happy facial expressions were paired with the negative words. The control condition for the *Expression* task consisted of a row of five Xs across

each facial expression (see Appendix B for examples). Each expression of each poser was shown three times and since there were a total of 16 faces, there were 48 control trials in the *Expression* task. The controls for the *Word* task were the same faces but distorted by pixelating the image so that each pixel was magnified by a factor of 16 and the luminance values were averaged. This resulted in a distorted face so that the expression could not be identified, but an image of a face and shoulders was still recognizable. These distorted faces were paired with each word three times. Thus, there was a total of 36 control trials in the *Word* task.

The Task order was counterbalanced along with response button order, and stimulus list. There were two stimulus lists. The order of presentation for the *Expression* and *Word* tasks was randomized, and restrictions were applied within each stimulus list so that no more than three of the same expression or emotion word type occurred in a row. The Stroop stimuli were presented randomly and centrally 2 degrees of visual angle above or below a central fixation point. Visual angles were measured from the middle of the word. Each experiment consisted of Button Learning trials, Practice trials, and then Experimental trials, with the numbers of each type of trial given below. Prior to every experiment except the Central *Happy and Sad* experiment subjects completed a Word Valence Test.

#### *Word Valence Test.*

During the *Happy and Sad* Experiment, some subjects informed the experimenter that they were unsure of the meaning of some of the words, thereby suggesting they were not able to accurately judge the valence of those words. So for the *Happy and Angry*

Experiment a list of the 12 words used in the experiment was made, and presented to each subject before the Button Learning Trials. The experimenter read each word to the subject while pointing to the word. The subject then identified if they knew the definition of the word and whether the word's valence was positive or negative. If a subject did not know the definition, they were given the definition. If a subject misidentified the valence of the word, they were corrected.

*Button Learning trials.*

To ensure that the participants visually fixated centrally, they were told that a cross would appear in the middle of the screen where they should keep their eyes focused. A word would briefly follow the cross. They were to respond as quickly as possible to whether the word was positive or negative by pressing one of two buttons on the mouse using either their index or middle finger. One button was designated as the *positive* response button and the other as the *negative* response button. Auditory feedback was provided by the computer. A low pitched tone (200Hz) indicated a mistake, and a high pitched tone (2000Hz) signaled a correct response. There were six Button Learning trials.

*Practice trials.*

Ten practice trials followed the Button Learning trials. The participants were told that an expression (or word, depending on the Experimental task they were completing) would appear quickly on the screen following a central fixation cross. They were asked to judge whether the expression or word is positive or negative as quickly and as accurately as possible. Visual and auditory feedback were provided for the first six trials.

The subject received only auditory feedback for the remaining trials. If a subject performed at 70% or better, they moved on to the Experimental trials. No subject completed the Practice trials more than twice.

#### *Experimental trials.*

The subject then performed either the *Expression* or *Word* task. They were reminded to keep their eyes fixed on the cross and to respond to either the expression or the word (depending on which task they were performing). Each trial began with the appearance of a fixation cross (+) in the middle of the screen for a duration of 120 ms, followed by the Stroop stimulus for 300 ms. The fixation cross reappeared for 2000 ms till the end of the trial. Audio feedback occurred 300 ms after a response had been given. The next trial began with the presentation of a fixation cross. Upon completion of one task, a subject was taken through the Practice trials and then on to the Experimental trials for the other task.

#### Experiment 4 & 5: Lateralized Stroop Task: Expressions and Words

##### *Participants*

The participants were 64 undergraduate students of the University of North Texas. An equal number of males (16) and females (16) participated in each of the two experiments. Ages ranged from 18- 42 years old. All the participants spoke English as their native language and had normal or corrected to normal vision. The participants were right-handed as determined by the Edinburgh Handedness Inventory. They received extra credit course points for their participation in the study.

### *Stimuli*

The Stroop stimuli were the same stimuli used in Experiment 2 and 3.

### *Apparatus*

The apparatus were the same as in Experiments 2 and 3.

### *Procedure*

#### *Presentation.*

The Stroop stimuli were presented centered 2° to the right or left of the central fixation cross along the horizontal meridian. This ensured presentation to right visual field (RVF) or the left visual field (LVF). Presentation to the RVF or LVF was pseudo-randomized with the restriction that there were no more than three consecutive presentations to the same visual field.

As in Experiments 2 and 3 subjects were tested in either the *Happy and Angry* Experiment or the *Happy and Sad* Experiment. The *Word* task comprised 48 congruent and incongruent trials per visual field. There were 12 congruent and 12 incongruent trials for each of the two emotions per visual field, e.g. for the HAPPY emotion in the RVF, 12 happy facial expressions and positive words and 12 happy facial expressions and negative words respectively. The same controls used in the previous experiments were used in these experiments. Thus, the *Word* task had 18 control trials per visual field. The *Expression* task's congruent and incongruent trials were the same as those in the *Word* task. However, the *Expression* task had 24 control trials per visual field. Therefore, the total number of trials was equal in Experiments 2 and 4, and Experiments 3 and 5.



As in the other experiments, the Task orders were counterbalanced along with response button order, and stimulus list. The order of presentation for the combination of expression and word was such that no more than three of the same expression, or emotion word type, occurred in a row. The Word Valence Test was conducted before the Button Learning trials of each lateralized experiment. The Button Learning trials and Experimental task trials were exactly the same as in Experiments 2 and 3.

During the Practice trials in Experiments 2 and 3 it was noted that some subjects were initially unprepared for the brief presentation of the stimuli and would not respond to the first one or two practice trials. After which they would quickly catch on and make few mistakes. However, because of the first couple of trials, they would fail the 70% correct criterion and had to repeat the Practice trials. Thus, for the lateralized experiments the number of Practice trials was increased to 15, which resulted in fewer repetitions of the Practice trials. No subject completed the Practice trials more than twice.

## CHAPTER III

### RESULTS

#### Experiment 1: Accuracy Study of a Facial Expression Stimulus Set

Percent correct was calculated for each of the photographs displayed in the *Identification* task of the Accuracy Study. Eight male and eight female posers with the highest percent correct for Happy, Sad, and Angry facial expressions were selected and used in the Central and Lateralized Experiments (see Table 2). These posers were also chosen so that a close overall match of the percent correct for each expression and gender occurred. For example, the average percent correct for the four male posers expressing happiness (98%) closely matched the average percent correct for the four female posers expressing happiness (99%). In addition, the average percent correct for the male and female posers expressing happiness (96%) closely matched the average percent correct for the male and female posers (96%) expressing sadness.

#### General Analysis Procedures

##### *Experiments 2 & 3: Central and Lateralized Stroop Experiments*

Only RTs for correct responses with values greater than 200ms or less than 2000ms were used in the analyses. In addition, RTs and percent correct values that deviated 2.5 standard deviations or more from the cell means within an experiment were excluded. A subject was judged not to know the definition of a word if they missed it during the Word Test and/or incorrectly judged its valence in the experiment 50% of the

time or more. See Table 3 for numbers of excluded subjects per experiment. Newman-Keuls post hoc comparisons were conducted where appropriate with the significant  $p$  value  $< .05$  unless otherwise indicated.

*Central Stroop Experiments: Happy and Sad; Happy and Angry*

Separate analyses of variance (ANOVAs) were conducted on the *Expression* and *Word* tasks. The raw mean correct RTs and Accuracy were analyzed by  $2 \times 2 \times 6$  mixed factorial ANOVAs with Subject's Gender (male/female) as a between subject factor, Poser's Gender (male/female) and Expression-Word Combination (Positive expression-positive word, Positive expression-negative word, Negative expression-negative word, Negative expression-positive word, positive controls, and negative controls) as within subject factors.

To examine interference effects and control for variance due to irrelevant factors, the raw mean RTs of the control trials for each condition were averaged and subtracted from their respective averaged congruent and incongruent trials for each subject. For example, for the *Expression* task all the trials of Happy expressions (positive expression controls) made by female posers were averaged for each subject. The trials of female Happy expressions paired with positive words (congruent condition) were also averaged for each subject as well as the Happy expressions posed by females that were paired with negative words (incongruent condition). The averaged RTs of the positive control trials (Happy female expressions) was then subtracted from the averaged RTs of the positive congruent trials. If the congruent trials resulted in faster RTs than the control trials, the score was negative which suggests facilitation from the combination of Happy

expressions and positive words. If on the other hand the average of incongruent trials was slower than the average of the negative control trials, the score was positive which suggests interference from the incongruent negative words. Thus, these difference scores resulted in positive values representing interference and negative values representing facilitation.

The difference scores were analyzed initially by a 2 x 2 x 2 x 4 mixed factorial ANOVA with Subject's Gender (male/female) as a between subjects factor and Task (Expression/Word), Poser's Gender (male/female), and Expression-Word Combination (positive expression-positive word, positive expression-negative word, negative expression-negative word, negative expression-positive word) as within subject factors. These analyses permitted the examination of automaticity across the two tasks by providing an interference or facilitation measure for each task.

Since the main focus of the current study was the examination of interference effects when ignoring either the words or expressions, separate ANOVAs were then conducted for each task. These difference scores were analyzed by a 2 x 2 x 4 mixed factorial ANOVA with Subject's Gender (male/female) as a between subject factor and Poser's Gender (male/female), and Expression-Word Combination (Positive expression-positive word, Positive expression-negative word, Negative expression-negative word, Negative expression-positive word) as within subject factors.

## Experiment 2: Central *Happy and Sad*

### *RT*

#### *Expression Task.*

The expected quicker RT for a female's sad expression compared to a male's sad expression failed to be revealed in a planned comparison,  $F(1,30) < 1$ , ns. The main effect of Expression-Word Combination was significant,  $F(5,150) = 3.99$ ,  $p < .01$ . Planned comparisons were conducted to examine the facilitation and interference effects. Congruent and incongruent expression-word combinations were tested for significance against their respective controls. They revealed that the congruent combination of Happy expression-positive word was responded to marginally faster than the Happy control expressions,  $F(1,30) = 3.93$ ,  $p = .06$ . An interaction of Poser's Gender x Expression-Word Combination was significant,  $F(5,150) = 3.56$ ,  $p < .01$  (see figure 1). Post hoc analyses indicated slower RT when positive words were paired with sad facial expressions made by females ( $M = 713$  ms) than when paired with sad facial expressions made by males ( $M = 680$  ms).

#### *Word Task.*

There was a significant main effect of Poser's Gender indicating that when responding to the valence of the words, expressions posed by males resulted in longer RT ( $M = 806$  ms) than expressions posed by females ( $M = 797$  ms),  $F(1,30) = 5.63$ ,  $p < .05$ . Although the RT differences between the male and female posers were small, this is a robust effect which is seen throughout the various experiments as well as in the difference scores analyses. The main effect of Expression-Word Combination was

significant,  $F(5,150) = 10.24, p < .01$ . Again planned comparisons examined the interference and facilitation effects. They revealed that the congruent combination of Happy expression-positive word ( $M = 783$  ms) was responded to quicker than the positive control words ( $M = 798$  ms),  $F(1,30) = 4.54, p < .05$ ; the incongruent combination of Happy expression-negative words ( $M = 836$  ms) was responded to slower than the negative control words ( $M = 783$  ms),  $F(1,30) = 6.20, p < .05$ ; and the incongruent condition of Sad expression-positive word ( $M = 814$  ms) was responded to slower than the positive control words ( $M = 798$  ms),  $F(1,30) = 23.23, p < .05$ . Thus, suggesting as predicted that the expressions resulted in interference effects by slowing the responses of valence judgments to the words in the incongruent conditions. The congruent conditions (expression and word valence match) resulted in facilitation effects.

### *Difference Scores*

#### *Expression and Word Tasks.*

The female subjects exhibited interference ( $M = 19$ ) compared to the male subjects ( $M = -4$ ),  $F(1,30) = 11.89, p < .01$ . The main effect of Task approached significance,  $F(1,30) = 4.16, p = .05$ . The *Word* task resulted in interference ( $M = 17$ ) compared to the *Expression* task ( $M = -1$ ). Thus, the facial expressions interfered more with the valence words than *vice versa*, suggesting that evaluating the valence of facial expressions is a more automatic process than evaluating the valence of words. The interaction of Posers' Gender x Task was also significant with the male posers' pictures resulting in facilitation in the *Expression* task ( $M = -8$ ) and interference in the *Word* task ( $M = 23$ ),  $F(1,30) = 6.27, p < .05$ .

### *Expression Task.*

Female subjects showed an interference effect ( $M = 11.4$ ) from the words although male subjects demonstrated a facilitation effect ( $M = -13.6$ ),  $F(1,30) = 6.20$ ,  $p < .05$ . The main effect of Expression-Word Combination was significant,  $F(3,90) = 3.78$ ,  $p < .05$  (see figure 2a). Planned comparisons revealed that the congruent combination of Happy expression-positive word ( $M = -15$ ) facilitated responses compared to the incongruent combination of Happy expression-negative word ( $M = 12$ ),  $F(1,30) = 8.94$ ,  $p < .05$ . In addition, the congruent combination of Sad expression-negative word ( $M = -10$ ) resulted in facilitation compared to the incongruent combination of Sad expression-positive word ( $M = 9$ ),  $F(1,30) = 5.15$ ,  $p < .05$ . In sum, the positive words facilitated and negative words interfered with responses to the expression. The words interfered with female subjects' responses.

### *Word Task.*

There was a significant main effect of Poser's Gender where the male posers' expressions resulted in relatively greater interference ( $M = 22.8$ ) than the female posers' expressions ( $M = 10.4$ ) when responding to the valence of the words,  $F(1, 30) = 5.12$ ,  $p < .05$ . The main effect of Expression-Word Combination was significant,  $F(3, 90) = 10.89$ ,  $p < .01$  (see figure 2b). Planned comparisons revealed that both incongruent pairs [Happy expression-negative word ( $M = 49.6$ ); Sad expression-positive word ( $M = 16.6$ )] resulted in more interference than the congruent pairs [Happy expression-positive word ( $M = -11.6$ ); Sad expression-negative word ( $M = 11.9$ )],  $p < .001$ . Surprisingly, the happy expressions actually resulted in a slightly greater interference of 9 ms than the sad

expressions when mismatched with the word valences. This is contrary to the expected greater interference from negative expressions. When responding to the valence of the words, facial expressions made by males captured attention and interfered with the word judgment task. The irrelevant dimension of the facial expressions resulted in robust interference effects on evaluating the valence of the words.

### *Accuracy*

Given the high accuracies observed for all conditions (never under 90%), accuracy analyses are not reported because comparisons of their results cannot be considered meaningful with so many subjects at ceiling levels. The output of the analyses were used to verify that there were not significant effects of the valence of the control stimuli (that is, to test that there were not accuracy differences for positive versus negative stimuli). The analyses revealed that there was not a significant difference between the Happy ( $M = 94\%$ ) and Sad expressions ( $97\%$ ), nor were the positive ( $M = 92\%$ ) and negative words ( $M = 95\%$ ) differentiated.

### *Discussion*

Robust Stroop interference effects were seen for both tasks. As hypothesized the happy and sad expressions affected the valence evaluation of the words. The positive and negative words also affected the valence judgments of the expressions. However, the expressions caused more interference than the words overall. A gender effect was seen when responding to the expressions so that the words cause greater interference for the female subjects than the male subjects. The congruent combination of Happy expression-positive word results in a robust facilitation in both tasks. The expressions made by males



resulted in greater facilitation in the *Expression* task and more interference in the *Word* task. Thus, the male posers' expressions seem to be more salient than the facial expressions made by females. The predicted result of sadness expressed by females being responded to faster than when expressed by males was not found. Nor was the expected greater interference of negative expressions compared to positive expressions in the incongruent conditions evident.

### Experiment 3: Central *Happy and Angry*

*RT*

#### *Expression Task.*

None of the effects were significant nor were any of the planned comparisons.

#### *Word Task.*

There was a significant main effect of Poser's Gender indicating that the male posers' expressions resulted in slower RT ( $M = 809$  ms) than the female posers' expressions ( $M = 796$  ms) when responding to the valence of the words,  $F(1, 30) = 11.88$ ,  $p < .01$ . The main effect of Expression-Word Combination was significant,  $F(5, 150) = 15.94$ ,  $p < .01$ . Planned comparisons revealed that all the congruent and incongruent pairings were slower than their respective controls. The congruent pairing of Happy expression-positive word ( $M = 792$  ms) and the incongruent pairing of Angry expression-positive word ( $M = 836$  ms) both resulted in slower RT compared to the positive control words ( $M = 772$  ms),  $F(1, 30) = 13.38$ ,  $p < .01$ ;  $F(1, 30) = 87.41$ ,  $p < .01$  respectively. The congruent pairing of Angry expression-negative word ( $M = 804$  ms) and the

incongruent pairing of Happy expression-negative ( $M = 836$  ms) word both resulted in slower RT compared to the negative control words ( $M = 780$  ms),  $F(1, 30) = 8.72, p < .01$ ;  $F(1, 30) = 21.71, p < .01$ , respectively.

### *Difference Scores*

#### *Expression and Word Tasks.*

The main effect of Task was significant,  $F(1,30) = 25.50, p < .01$ . The *Expression* task resulted in facilitation ( $M = -1$ ) and the *Word* task resulted in interference ( $M = 40$ ). Thus, the facial expressions interfered more with the valence words suggesting that evaluating facial expressions is a more automatic process than evaluating words. The interaction of Posers' Gender x Task was also significant with the pictures of male posers' resulting in more facilitation in the *Expression* task ( $M = -6$ ) and more interference in the *Word* task ( $M = 50$ ),  $F(1,30) = 6.27, p < .05$ .

#### *Expression Task.*

The main effect of Expression-Word Combination was significant,  $F(3,90) = 2.97, p < .05$ . However, planned comparisons revealed that only the Angry expressions exhibited facilitation and interference from the words. The congruent combination of Angry expression-negative word resulted in facilitation ( $M = -3.2$ ) compared to the incongruent combination of Angry expression-positive words ( $M = 15.8$ ),  $F(1, 30) = 8.61, p < .01$  (see figure 3a).

#### *Word Task.*

There was a significant main effect of Poser's Gender indicating that the male posers' expressions resulted in greater interference ( $M = 49.6$ ) than the female posers'

expressions ( $M = 30.8$ ) when responding to the valence of the words,  $F(1, 30) = 11.89$ ,  $p < .01$ . The main effect of Expression-Word Combination was significant,  $F(3, 90) = 7.89$ ,  $p < .01$  (see figure 3b). Planned comparisons revealed that both incongruent pairs resulted in more interference than their respective congruent pairs. The Happy expression-positive word ( $M = 19$ ) pair resulted in less interference compared to the incongruent combination of Angry expression-positive word ( $M = 64$ ),  $F(1, 30) = 38.64$ ,  $p < .05$ . In addition, the congruent combination of Sad expression-negative word ( $M = 25$ ) resulted in less interference compared to the incongruent combination of Happy expression-negative word ( $M = 35$ ),  $F(1, 30) = 8.50$ ,  $p < .05$ . The angry expressions resulted in a 17 ms greater interference than the happy expressions when incongruent from the valence of the words.

#### *Accuracy*

Although accuracy analyses were conducted, their results are not reported because the accuracies were once again so high (never under 90%) that comparisons amongst them cannot be considered meaningful. The output of the analyses were used to verify that there were not significant effects of the valence of the control stimuli (that is, to test that there were not accuracy differences for positive versus negative stimuli). The analyses revealed that there was not a significant difference between the Happy ( $M = 94\%$ ) and Angry expressions ( $M = 96\%$ ), nor were the positive ( $M = 94\%$ ) and negative words ( $M = 96\%$ ) differentiated.

## *Discussion*

For the Central *Happy and Angry* experiment, interference and facilitation effects were seen for only the *Word* task. As hypothesized, the happy and angry expressions interfered with the valence evaluation of the words and the expressions resulted in overall more interference than the words. When an interference effect occurred with words it was limited to only positive words which interfered with the valence judgments of angry expressions. The happy expressions were not affected by either valence of the words. The angry expressions when mismatched with the word valences resulted in a 17 ms greater interference than the happy expressions when in the incongruent conditions. This suggest that the angry expressions cause a greater interference effect than the happy expressions. The male posers' expressions were once again more salient than the facial expressions made by females as seen by the male expressions greater facilitation in the *Expression* task and greater interference in the *Word* task. In fact, the interference effects induced by the male expressions appear stronger in this experiment than experiment 2. However, anger expressed by males was not responded to faster than anger expressed by females as had been predicted.

## General Analysis Procedures

### *Lateralized Stroop Experiments: Happy and Sad; Happy and Angry*

Reaction times and Accuracy were analyzed by 2 x 2 x 2 x 6 mixed factorial ANOVAs with Subject's Gender (male/female) as a between subject factor and Poser's Gender (male/female), Visual Field (Left visual field/Right visual field) and Expression-Word Combination (positive expression-positive word, positive expression-negative

word, negative expression-negative word, negative expression-positive word, positive controls, and negative controls) as within subject factors.

The difference scores were analyzed by 2 x 2 x 2 x 4 mixed factorial ANOVAs with Subject's Gender (male/female) as a between subject factor and Task (Expression/Word), Poser's Gender (male/female), and Expression-Word Combination (positive expression-positive word, positive expression-negative word, negative expression-negative word, negative expression-positive word) as within subject factors. These analyses allowed the examination of automaticity between the two tasks by providing an interference or facilitation measures for each task.

Since the main focus was the examination of interference effects when ignoring either the words or expressions, separate ANOVAs were conducted on each task. The difference scores were analyzed by 2 x 2 x 2 x 4 mixed factorial ANOVA with Subject's Gender (male/female) as a between subject factor and Poser's Gender (Male/Female), Visual Field (Left visual field/Right visual field) and Expression-Word Combination (positive expression-positive word, positive expression-negative word, negative expression-negative word, negative expression-positive word) as within subject factors.

#### Experiment 4: Lateralized Happy and Sad

*RT*

##### *Expression Task.*

The expected quicker RTs for a female's sad expression compared to a male's sad expression failed to be revealed in a planned comparison,  $F(1,30) = 1.62$ , ns. The main effect of Visual Field was not significant,  $F(1, 30) < 1$ . Nor did planned comparisons

indicate a valence advantage for either visual field. Thus, the RVF did not demonstrated an overall advantage for expressions, nor was there an advantage for happy expressions in the RVF/LH or an advantage for sad expressions in the LVF/RH. Although the main effect of Expression-Word Combination was not significant,  $F(5,150) = 1.67, p > .05$ , planned comparisons revealed that the congruent combination of Happy expression-positive word was responded to faster ( $M = 684$  ms) than the Happy control expressions ( $M = 700$  ms),  $F(1, 30) = 4.57, p < .04$ . An interaction of Posers' Gender x Expression-Word combination was significant,  $F(5,150) = 7.11, p < .01$  (see figure 4). It appears revealed (and post hoc analyses) that the incongruent conditions were responded to differently depending on the gender of the person making the expression. For example, when a Happy expression was made by a male and the words were negative, the expressions were responded to slower ( $M = 723$  ms) than when a female made a Happy expression ( $M = 674$  ms). Furthermore, when a Sad expression was made by a female and the words were positive, the expressions were responded to slower ( $M = 719$  ms) than when a male made a Sad expression ( $M = 680$  ms). So the opposite valenced word interfered with judging happiness expressed by males and sadness expressed by females.

#### *Word Task.*

The main effect of Visual Field was significant,  $F(1, 30) = 5.92, p < .02$ . As predicted, when responding to the valence of the words overall the RVF/LH ( $M = 794$  ms) resulted in faster RT than the LVF/RH ( $M = 807$  ms). The main effect of Expression-Word Combination was significant,  $F(5,150) = 10.05, p < .05$ . Planned comparisons revealed that the incongruent conditions of Happy expression-negative word ( $M = 830$

ms) and Sad expression-positive word ( $M = 817$  ms) were responded to slower than their respective negative ( $M = 784$  ms) and positive ( $M = 791$  ms) word controls. An interaction of Posers' Gender x Visual Field x Expression-Word Combination was significant,  $F(5,150) = 2.72, p < .05$  (see figure 5). That interaction was qualified by an interaction of Subjects' Gender x Posers' Gender x Visual Field x Expression-Word Combination which was significant,  $F(5,150) = 2.34, p < .05$ .

To elucidate this 4-way interaction, the *Word Task* analysis was examined for each Visual Field in a 2 (Subjects' Gender) x 2 (Posers' Gender) x 6 (Expression-Word combination) ANOVA. The analysis for the LVF revealed that the main effect of Expression-Word Combination was significant,  $F(5,150) = 10.05, p < .05$ . Planned comparisons revealed the same pairs as before were significant. An interaction of Posers' Gender x Expression-Word Combination was significant,  $F(5,150) = 2.46, p < .05$  (see figure 6a). Post hoc analyses indicate that when males expressed sadness, responses to their faces were slower when the words were negative ( $M = 832$  ms) compared to females' Sad expressions ( $M = 789$  ms). In fact, regardless of the valence of the word, RTs to males' Sad expressions were the same. Thus, sadness expressed by females had faster responses in the congruent condition and slower responses in the incongruent condition, while sadness expressed by males when presented in the LVF caused overall slower responses. When considering the RVF, the only significant effect was the main effect of Expression-Word Combination,  $F(5,150) = 8.19, p < .05$ . Planned comparisons revealed the same pairs as before were significant. Interestingly there were no interactions with Posers' Gender x Expression-Word Combination within the RVF,  $F$

(5,150) = 1.60,  $p > .05$  (see figure 6b). Thus, the interactions of Posers' Gender were only seen when the stimuli were presented in the LVF/RH.

### *Difference Scores*

#### *Expression and Word Tasks.*

The main effect of Task was significant,  $F(1,30) = 7.43, p < .01$ . The *Expression* task resulted in facilitation ( $M = -4.2$ ) and the *Word* task ( $M = 18.5$ ) resulted in interference. Thus, the facial expressions interfered more with the valenced words suggesting that evaluating facial expressions is a more automatic process than evaluating the valence of words.

#### *Expression Task.*

The main effect of Expression-Word Combination approached significance,  $F(3,90) = 2.64, p = .05$  (see figure 7a). Planned comparisons revealed that the congruent combinations facilitated responses and the incongruent combinations interfered with responses. The Happy expression-positive word resulted in relative facilitation ( $M = -5.6$ ) compared to the incongruent combination of Happy expression-negative word ( $M = -1$ ),  $F(1, 30) = 4.83, p < .05$ . The congruent combination of Sad expression-negative word resulted in facilitation ( $M = -8.5$ ) compared to the incongruent combination of Sad expression-positive words ( $M = 8.5$ ),  $F(1, 30) = 8.61, p < .01$ . An interaction of Posers' Gender x Expression-Word Combination was significant,  $F(3,90) = 3.36, p < .05$  (see figure 8). It appears that as in the RT data, the incongruent conditions affected responses to male and female posers' expressions differently. Responses to the male posers revealed interference when the expression was Happy and the words were negative ( $M =$



13) compared to female expressions in that condition ( $M = -15$ ). Happiness expressed by females was responded to the same regardless of the valence of the words. When the expressions were sad, the positive word interfered more with the responses if they were made by females compared to males. As with happiness when expressed by females, sadness expressed by males was responded to the same regardless of the valence of the words. Post hoc analyses did not reveal these differences to be significant.

#### *Word Task.*

The main effect of Expression-Word Combination was significant,  $F(3, 90) = 10.96, p < .01$  (see figure 7b). Planned comparisons revealed that both incongruent pairs resulted in more interference than the congruent pairs. The Happy expression-positive word ( $M = -8.7$ ) resulted in facilitation compared to its incongruent counterpart of Sad expression-positive word ( $M = 26.04$ ),  $F(1, 30) = 14.76, p < .01$ . The Sad expression-negative word ( $M = 10.8$ ) resulted in relatively less interference compared to the incongruent pair of Happy expression-negative word ( $M = 45.8$ ),  $F(1, 30) = 35.92, p < .01$ . The sad and happy expressions resulted in equal interference when subjects responded to the words in the incongruent conditions (with less than 1 ms difference). An interaction of Posers' Gender x Visual Field x Expression-Word Combination was significant,  $F(3,90) = 2.95, p < .05$  (see figure 9). Although none of the post hoc tests were significant, visual inspection of the interaction suggests that in general the male posers' pictures result in greater interference than the female posers' pictures especially in the congruent conditions. In addition, this relative interference varies depending on the expression and visual field. For example, when the Happy expression-positive word

condition was shown in the RVF/LH the male Happy expressions show interference and the female posers pictures resulted in facilitation. However, in the Sad expression-negative word condition the male posers interfered more when the combination was shown in the LVF/RH.

### *Accuracy*

Given the high accuracies observed for all conditions (never under 90%), accuracy analyses are not reported because comparisons of their results cannot be considered meaningful with so many subjects' data at ceiling levels. The output of the analyses was used to verify that there were not significant effects of the valence of the control. The analyses revealed that there was not a significant difference between the Happy ( $M = 95\%$ ) and sad expressions ( $M = 97\%$ ), nor were the positive ( $M = 94\%$ ) and negative words ( $M = 96\%$ ) differentiated.

### *Discussion*

Whereas the RVF/LH did not demonstrate an overall advantage for expressions, stimuli presented to the LVF/RH did show the expected advantage as indicated by faster RTs when subjects responded to the words. Additionally, neither hemisphere showed an advantage for specific emotional expressions as predicted by the valence hypothesis. Interference and facilitation effects were seen in both tasks. As hypothesized the happy and sad expressions interfered with the valence evaluation of the words to a greater extent than words affected judgments of expressions, suggesting that valence judgments of expressions are a more automatic process. However, the negative sad expressions and the positive happy expressions resulted in similar interference when mismatched in valences

with the words. This is in contrast to the predicted greater interference from negative expressions than positive expressions. Again, the expected advantage in responses to sadness expressed by females compared to male sad expressions was not seen.

It appears that positive and negative words interfere differently with happy and sad expressions depending on the gender of the person making the expression. The positive words robustly interfere with the judgment of sadness expressed by females as seen in both the Central and Lateralized experiments, and happiness expressed by males had interference from negative words only in the current lateralized experiment. In addition, expressions made by males seem to be more salient than those made by females as seen by greater interference when responding to words. This effect is qualified by visual field influences and matching emotional valence of the expressions and words. The happy expressions made by males interfered with judging positive words when in the RVF/LH whereas sad expressions interfered with judging negative words when in the LVF/RH.

#### Experiment 5: Lateralized *Happy and Angry*

*RT*

##### *Expression Task.*

The expected quicker RT for a female's sad expression compared to a male's sad expression failed to be revealed in a planned comparison,  $F(1,30) < 1$ , ns. As expected the main effect of Visual Field was significant with the expression-word combination responded to faster when presented in the left visual field ( $M = 680$  ms) than the right visual field ( $M = 697$  ms),  $F(1, 30) = 13.69$ ,  $p < .01$ . But planned comparisons again

failed to indicate a valence advantage for either visual field. So the RVF/LH failed to exhibit an advantage for happy expressions and the LVF/RH failed to show an advantage for angry expressions. An interaction of Subjects' Gender x Posers' Gender x Visual Field was significant,  $F(1,30) = 7.71, p < .01$  (see figure 10). Post hoc analyses revealed that the female subjects responded slower to the expressions made by males when the stimulus combination was presented in the RVF ( $M = 715$  ms) than the LVF ( $M = 685$  ms). In addition, the female subjects ( $M = 715$  ms) compared to male subjects ( $M = 686$  ms) responded slower to expressions posed by males when presented in the RVF. An interaction of Subjects' Gender x Posers' Gender x Visual Field x Expression-Word Combination was significant,  $F(5,150) = 2.62, p < .05$ .

This interaction was then examined using a 2 (Subjects' Gender) x 2 (Visual Field) x 6 (Expression-Word combination) ANOVA for each Posers' Gender. The analysis for the Male Posers did not reveal a significant interaction of Subjects' Gender x Visual Field x Expression-Word Combination,  $F(5,150) = 1.95, p > .05$  (see figure 11a). The analysis for the Female Posers revealed a significant interaction of Subjects' Gender x Visual Field x Expression-Word Combination,  $F(5,150) = 2.68, p < .05$ . However, neither visual inspection nor post hoc tests suggested a clear picture of the interaction (see figure 11b).

#### *Word Task.*

There was a significant main effect of Poser's Gender indicating that the male posers' expressions resulted in slower RT ( $M = 805$  ms) than the female posers' expressions ( $M = 793$  ms) when responding to the valence of the words,  $F(1, 30) = 10.31,$

$p < .01$ . The main effect of Expression-Word Combination was significant,  $F(5, 150) = 22.13, p < .01$ . Planned comparisons revealed that both incongruent pairs resulted in slower RTs than the control words. The incongruent pairing of Happy expression-negative word ( $M = 838$  ms) and the incongruent Angry expression-positive word ( $M = 826$  ms) pairs were slower than their respective control words ( $M = 783$  ms;  $770$  ms),  $F(1, 30) = 44.45, p < .01$ ;  $F(1, 30) = 41.89, p < .01$  respectively. The congruent pairing of Angry expression-negative word ( $M = 804$  ms) resulted in slower RT compared to the negative control words,  $F(1, 30) = 5.14, p < .05$ . The main effect of Visual Field was not significant,  $F(1, 30) < 1$ . However, an interaction of Visual Field x Expression-Word Combination was significant,  $F(5, 150) = 3.15, p < .01$  (see figure 12). Post hoc analyses revealed the Angry expression-negative word pairs were responded to faster when presented in the RVF ( $M = 783$  ms) than the LVF ( $M = 824$  ms). The Angry expression-positive word pairs were responded to slower when presented in the RVF ( $M = 883$  ms) than the Angry congruent condition.

### *Difference Scores*

#### *Expression and Word Task.*

The main effect of Task was significant,  $F(1, 30) = 17.86, p < .01$ . The *Expression* task had less interference ( $M = 1$ ) than the *Word* task ( $M = 34$ ). Thus, the facial expressions interfered more with the valence words suggesting that evaluating facial expressions is a more automatic process than evaluating words.

### *Expression Task.*

The main effect of Expression-Word Combination was significant,  $F(3,90) = 3.96, p < .05$  (see figure 13a). Planned comparisons revealed that only the congruent combination of Happy expression-positive word resulted in facilitation ( $M = -18$ ) compared to the incongruent combination of Happy expression-negative words ( $M = 0$ ),  $F(1, 30) = 6.48, p < .05$ . An interaction of Subjects' Gender x Posers' Gender x Visual Field x Expression-Word Combination was significant,  $F(3,90) = 4.57, p < .05$ .

The 4-way interaction was then analyzed for each Visual Field in 2 (Subjects' Gender) x 2 (Posers' Gender) x 4 (Expression-word Combination) ANOVAs. An interaction of Subjects' Gender x Posers' Gender x Expression-word Combination was significant for the LVF,  $F(3,90) = 5.28, p < .01$  (see figure 14a). Although the results were complex, for the LVF it appeared that facilitation occurred when subjects' gender matched that of the posers' and interference occurred when the genders were opposite. This interaction also seemed to be greater for the Happy expression-positive and negative word combinations. Post hoc tests indicated the male subjects showed more facilitation for male posers than female subjects in the Happy expression-positive word combination. In addition, male subjects showed interference when responding to the Angry expression-negative word when a male poser made the expression compared to the Happy expression congruent combination. Although the RVF analysis is not significant [ $F(3,90) = 1.45, p > .05$ ], it appeared that the general trends seen in the LVF reverse in the RVF (see figure 14b).

### *Word Task.*

There was a significant main effect of Poser's Gender indicating that the male posers' expressions resulted in greater interference ( $M = 43$ ) than the female posers' expressions ( $M = 25$ ) when responding to the valence of the words,  $F(1, 30) = 10.31, p < .01$ . The main effect of Expression-Word Combination was significant,  $F(3, 90) = 10.96, p < .01$  (see figure 13b). Planned comparisons revealed that both incongruent pairs resulted in more interference than the congruent pairs. The Happy expression-positive word ( $M = 2$ ) resulted in less interference than its incongruent counterpart of Angry expression-positive word ( $M = 56$ ),  $F(1, 30) = 38.28, p < .01$ . The Angry expression-negative word ( $M = 21$ ) resulted in less interference than its incongruent pair of Happy expression-negative word ( $M = 56$ ),  $F(1, 30) = 16.09, p < .01$ . The angry expressions resulted in 19 ms greater interference than the happy expressions when paired with incongruent words. An interaction of Subjects' Gender x Visual Field x Expression-Word Combination was significant,  $F(3, 90) = 3.16, p < .05$  (see figure 15). Although none of the post hoc tests were significant, visual inspection of the interaction suggest that in general the male subjects when responding to the words demonstrate facilitation effects when the stimulus is presented in the RVF and interference effects when presented in the LVF. The female subjects tend to exhibit more interference when the expressions and words are incongruent and presented in the RVF.

### *Accuracy*

Although accuracy analyses were conducted, their results are not reported because the scores were close to ceiling levels (never under 90%). To verify that the valence

control stimuli were not judged significantly differently, post hoc tests were conducted.

The Happy ( $M = 95\%$ ) and Angry expressions ( $M = 96\%$ ) were not judged differently in accuracy, nor were the positive ( $M = 97\%$ ) and negative words ( $M = 97\%$ ).

### *Discussion*

As hypothesized when the expression-word pairs were presented in the LVF for the *Expression* task they were responded to faster than when viewed in the RVF. However, the *Word* task failed to exhibit a RVF advantage. Additionally, neither hemisphere showed an advantage for specific emotional expressions as predicted by the valence hypothesis. Interference effects were more robust for the *Word* task. Again as hypothesized, the happy and angry expressions interfered with the valence evaluation of the words to a greater extent than words affected expressions. In contrast to the Central *Happy and Angry* experiment, recognizing happy facial expressions was interfered with by negative words. The male posers expressions were once again more salient than the facial expressions made by females. As predicted the negative angry expressions resulted in greater interference (17 ms) than the happy expressions when paired with incongruent valence words.

The addition of visual field as a variable resulted in interesting interactions involving subjects' gender. The male subjects show a facilitation effect to the male posers when presented in the LVF, although the female subjects show an interference effect. Male subjects when responding to male expressions show a facilitation effect when the expression was happy and the word was positive and an interference effect when the



expression was sad and the word was negative. An effect of subjects' gender was only seen in this experiment.

## CHAPTER IV

### GENERAL DISCUSSION

The main focus of this investigation was to examine the automaticity of facial expression recognition through valence judgments in a modified Stroop paradigm. In addition, biases in valence judgments of male and female facial expressions and a possible hemispheric asymmetry in processing affective information were also examined. Four major findings emerged. First, the valence of facial expressions was processed automatically as demonstrated by the robust interference effects. Second, male faces regardless of the emotion, interfered with processing the valence of the words. Third, the gender of the poser did not result in biases in recognizing either anger or sadness. Finally, the emotionality of the facial expressions and words was processed similarly by the left and right hemispheres; thus, neither the valence hypothesis nor the right hemisphere hypothesis was supported.

#### *Interference effects*

The ability of one process to draw attention and impinge on the cognitive resources of another process is one indicator of automaticity. Because affective information has biological and social significance, it is an excellent candidate for automatic processing. Several lines of research have indicated that affective information is in fact processed automatically. For example, negative and positive valence words or personality traits have been shown to influence impression formation or preference

responses (Kihlstrom, 1987; Kitayama, 1991; Bargh, 1989). Visual search paradigms have demonstrated automaticity for schematic faces (Hansen & Hansen, 1994; Gilboa-Schechtman, Foa, & Amir, 1999; Mogg & Bradley, 1999; White, 1995). Negative line drawings of animals have resulted in interference of word reading in a Stroop picture-word task (De Houwer & Hermans, 1994). The current results extend these previous findings of automatic processing of affective stimuli to the valence categorization of facial expressions.

As predicted, in all experiments robust interference from the facial expressions was seen when judging the valence of words. The happy, sad, and angry facial expressions also facilitated responses to the words when the expressions matched the words' valences. Furthermore, as hypothesized the results indicated that judging the valence of expressions was a more automatic process than judging the positive and negative value of words.

The continuum theory of automaticity suggests that one process may be more or less automatic than another (MacLeod & Dunbar, 1988). Support of this theory was demonstrated in each experiment by the occurrence of stronger interference effects when subjects responded to the valence of words than to the valence of expressions. Interference effects caused by the positive and negative words were seen in both of the *Happy and Sad* experiments; however, they were not consistently seen in the *Happy and Angry* experiments. In fact, only positive words interfered with angry expressions in the central *Happy and Angry* experiment whereas in the lateralized *Happy and Angry* experiment, negative words interfered with happy expressions. A possible explanation of

the interference caused by the negative words with the happy expressions is that in a lateralized presentation the complex stimulus is viewed peripherally, and negative words representing anger such as *rage* and *furious* may activate arousal and draw attention away from the non-threatening happy expressions. In this same condition, the angry expressions were more salient than the positive words. The distraction caused by the negative words may have resulted because the stimulus appeared in the corner of the eye. Thus, as would be expected from our reliance on basic survival mechanisms, attention was drawn to the possible threat in the environment regardless of the modality of the threatening information.

The predicted greater interference of negative expressions on word valence judgments was only seen for angry expressions. Sad expressions incongruent to the word valence did not cause any more interference than the happy expressions. The inconsistent interference from both negative emotions could be explained by recognizing the differences among the two negative emotions. Although sad and angry are both negative emotions, they can be further qualified by their degree of pleasure and arousal. Russell (1980) would describe angry as falling in the dimension of high arousal and medium displeasure and sadness would be low arousal and medium displeasure. The arousal component of angry expressions is closely linked to survival in that it prepares the person for possible attack heightens awareness for a possible threatening situation. Thus, it is unsurprising that the high arousal characteristic of anger would cause greater interference than sadness.

### *Posers' Gender effects*

When the task was responding to the valence of the words, in both central experiments and the lateralized *Happy and Angry* experiment, expressions made by males resulted in greater interference effects than expressions made by females. Men's expressions of happiness, sadness, or anger seem to be more salient than the same expressions made by women. Such salience was seen regardless of the gender of the subject.

Women are believed to experience and express a much wider range of emotions than men (Plant, Hyde, Keltner & Devine, 2000; Fabes & Martin, 1991). For example, happiness and sadness are believed to be expressed more often by women than men. It is possible that this frequency of expression contributed to these findings because research has indicated that attention is drawn to stimulus features that are infrequent (Bargh, 1989). Since females are believed to express sadness and happiness more often, then the occurrence of these expressions is not novel and would not warrant attention. However, the infrequency of these expressions made by males would make them novel and likely more salient. Additionally, males are believed to have a greater propensity to behave aggressively than females (Hyde, 1984). Therefore, at a brief presentation time as in these experiments, the expressions made by males may require additional attention so that they may be evaluated for the potential of threat. This contrasts with the females' expressions, which regardless of the expression would pose less potential threat. The findings that attention is drawn to threatening cues (angry face) before complete analysis of the stimulus can occur complements other researchers findings (Esteves & Ohman, 1993;

Ohman, 1992). Thus, it would seem that for survival purposes it would be effective for a male face to draw attention so that further evaluation of potential threat may occur.

The expected biases in the ease of recognition of anger expressions expressed by males and sadness expressed by females were not revealed. However, it is likely that the lack of this effect could be attributed to the initial choices of posers. The male and female posers were selected based on their equivalence in the expression of the emotions (see Table 2). Controlling for such equivalence is not done in other studies. For example, studies using Ekman's and Friesen's (1976) set could have the rated accuracy of the male and female poses vary from 74% to 100% for each emotion. Erwin et al (1992) posers were chosen if there was a 70% agreement on the emotion expressed. Rotter and Rotter (1988) failed to give the percent of agreement on the expressions for their posers. In the present studies, faces were only included if the accuracy of identification was greater than 87%.

Therefore, the gender effects that other studies find may be a result of the poser set used. Their male and female posers may initially express different emotions more or less definitively. Findings have suggested that ambiguous expressions are judged in accordance to gender stereotypes (Plant, Hyde, Keltner & Devine, 2000). Thus, if in other studies the male and female posers' expressions are not clear, then any gender differences found may be a result of stereotypic responses and not true gender effects of the stimuli, that is they reflect observer bias rather than true expression effects.

Another important consideration is the reliability of the poser set as a function of stimulus exposure duration. For example, the Ekman and Friesen's (1976) set was

normed at a ten second presentation, yet many studies present their pictures at one second or less. The accuracies often vary from the normative study to the experimental study. Such variations may be the result of the experimental conditions, but they may also indicate that the set is not highly reliable. The accuracy levels of posers' expressions used in the current study remained at ceiling levels for all the experiments (as noted by the control expressions). The accuracies changed little from Experiment 1 (the *Accuracy* experiment) even though they were displayed for shorter durations in the other experiments. For example, the largest change was a decrease in accuracy of the Male posers' happy expressions from a 99% in the *Accuracy* experiment to a 94% in the central *Happy and Angry* experiment (see Table 4).

#### *Visual field effects*

Hemispheric advantages were expected depending on the task performed. The *Word* task was expected to exhibit an advantage for the RVF/LH since reading is predominately performed by the left hemisphere in right-handed people and such an advantage is seen in more traditional Stroop tasks (MacLeod, 1991; Peters, 1995). The *Expression* task, on the other hand, should have shown an advantage in the LVF/RH, the hemisphere attributed to processing faces (for reviews, see Bruyer, 1986; Rhodes, 1985). The RVF/LH advantage was seen for positive and negative words in the lateralized *Happy and Sad* experiment. The lateralized *Happy and Angry* experiment resulted in an LVF/RH advantage for the happy and angry facial expressions. However, these effects were not seen in both tasks across both lateralized experiments.

The lack of consistency may be attributed to the complexity of the tasks. Wessman and Banich (2000) have suggested that the complexity of the cognitive task drives the mode of processing (interhemispheric or intrahemispheric). Their findings indicate that more complex tasks will involve cooperation from both hemispheres whereas simple tasks are more reliant on intrahemispheric processing. Through a series of studies, they and others have provided support that the most efficient mode of processing occurs even though one hemisphere may typically dominate performance of a task (Banich & Belger, 1990; Banich & Passarotii, 1999; Weissman & Banich; Yoshizaki & Tsuji, 1998). They propose that although interhemispheric cooperation requires additional time for the information to cross the hemispheres via the corpus callosum, this cost is offset by the increase of computational power. In the present study, the complexity of evaluating the valence of one stimulus dimension likely taxed the processing capacity of the initially activated hemisphere thereby resulting in each hemisphere processing both stimuli without regard to specialization. Thus, explaining the weak effects of hemispheric specialization.

#### *Valence Hypothesis*

The predicted valence hypothesis of positive emotions having an advantage of processing in the RVF/LH and negative emotions having an advantage of processing in the LVF/RH was not seen in either of the lateral experiments. Furthermore, the hypothesis that the right hemisphere is superior in processing all emotion was not supported by the results either. Thus, neither hemisphere demonstrated an advantage in processing the affective information. Bowers and Helman (1984) suggested that both



hemispheres are capable of processing emotions, but that each hemisphere specializes in specific types of representations. For example, the right hemisphere specializes in perceptual representations of emotions whereas the left hemisphere specializes in verbal representations. So the present study may thereby have activated both hemispheres given the combined pictorial/verbal nature of the stimuli. Stone, Nisenson, Eliassen, and Gazzaniga (1996) examined hemispheric asymmetry for identification and discrimination of emotional expressions in a split-brain patient. They found that both hemispheres were equally capable of both tasks. A possible explanation of the lack of asymmetry in the current study could be that both hemispheres are capable of processing affective stimuli and the complexity of the tasks as discussed above favors interhemispheric processing.

#### *Future research*

An important study in the future would be to test the limitations of automatic processing of the valence categorization of facial expressions and words. The current research indicated that expressions both interfered with and facilitated valence evaluation of words depending on the condition tested. However, the tasks were the same for the two stimulus dimensions (valence categorization). A more stringent test of automaticity of expression recognition would be to test expression valence categorization against word reading. If the valence of the expressions interfered with a completely unrelated task such as word reading, then it would strongly indicate that expression recognition is an automatic process. Another interesting topic for research would be to see if the interference of words on the expressions could be manipulated by using stronger emotional words as used in emotional Stroop tasks (e.g. rape, murder, love).

Another future aspect of research would be to examine a possible interaction of positive and negative affect of the subjects with their responses to the emotional expressions and words. Anxiety is thought to be characterized by attentional biases for negative or threat stimulus where as the findings are mixed concerning depression and attentional biases (see Mogg & Bradley, 1999, for review). The current Stroop paradigm would allow the examination of attentional biases of subjects who scored high and low on a measure such as the PANAS, for angry and sad expressions (Watson, Clark, & Tellegen, 1988).

The surprising lack of hemispheric asymmetry warrants further investigation. To further examine the valence hypothesis it seems that the task should be simplified. One possibility would be to disentangle the stimulus dimensions by physically separating them. Then present the two dimensions unilaterally and bilaterally. The physical separation and bilateral presentation may allow any hemispheric advantages that exist to emerge.

### *Summary*

In summary, the current experimental findings contribute to the body of literature indicating that affective information is processed automatically. Specifically, the results indicate that valence categorization of facial expressions is an automatic process. The present results also suggest that positive and negative words are automatically categorized, but less robustly. One important implication of this study is on posers' gender effects and expression recognition. It appears crucial that the accuracy of specific emotional expressions made by male and female posers is controlled so that they are

equivalent. When such a control is in place, no gender biases in recognizing happy, sad, and angry expressions made by males and females was found. Moreover, briefly presented facial expressions made by males seem to be more salient than those made by females. The implication here is that since males have a greater propensity to behave aggressively than females, automatic evaluation of their expressions allows for insight into their intended actions, and this permits the observer to prepare accordingly. Another important contribution from this study is that the left and right hemispheres can equivalently recognize happy, sad, and angry expressions as well as evaluating positive and negative words. From an evolutionary standpoint, this equality in recognizing various expressions is beneficial. Evaluations could occur from either visual field, which would allow for faster responses to potentially threatening (and non-threatening) social situations. Additionally, the cooperation between the two hemispheres in processing complex and cognitively taxing stimuli also allows for potentially quicker evaluation, which would in turn allow for a quicker response.

APPENDIX A  
EDINBURGH HANDEDNESS INVENTORY

### Subject Questionnaire

Subject ID: \_\_\_\_\_

Sex: M F

Date: \_\_\_\_\_

Age: \_\_\_\_\_

Tasks: \_\_\_\_\_

Experimenter's Initials: \_\_\_\_\_

1. Do you consider yourself mostly right-handed, left-handed, or ambidextrous?

Right Left Ambi

2. Can you think of any situation in which you would use your non-preferred hand more than your preferred hand? ( if Yes, specify)

3. Which hand do you prefer to use to.....

	Left Hand		Both Equally	Right Hand	
	Always	Usually		Usually	Always
Draw?	_____	_____	_____	_____	_____
Throw a ball?	_____	_____	_____	_____	_____
Slice bread with a knife?	_____	_____	_____	_____	_____
Hold a match when striking it?	_____	_____	_____	_____	_____
Comb your hair?	_____	_____	_____	_____	_____
Brush your teeth?	_____	_____	_____	_____	_____
Cut with scissors?	_____	_____	_____	_____	_____
Hold a spoon when eating?	_____	_____	_____	_____	_____
Hammer something?	_____	_____	_____	_____	_____
Write?	_____	_____	_____	_____	_____

4. Which hand did your father use for most of these activities?

\_\_\_\_\_

### Subject Questionnaire

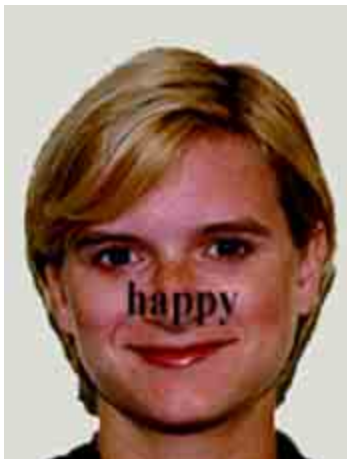
	Left Hand Always	Usually	Both Equally	Right Hand Usually	Always
5. Your mother?	_____	_____	_____	_____	_____
6. Brothers & Sisters? (specify number of each)	_____	_____	_____	_____	_____
7. Was anyone in your family ever forced to use their right hand?					
Yes	No	In yes, who?			
8. Which foot do you prefer to kick with?					
Left Always	Left Usually	Both Equally	Right Usually	Right Always	
9. Which eye do you use when using only one?			Left	Right	

APPENDIX B  
EXAMPLE STIMULI

Example stimuli for Congruent, Incongruent, Negative Expression Control, and Negative Word Control conditions. Note. Actual stimuli are in color.

Congruent Condition:

Happy expression-positive word



Incongruent Condition:

Sad expression-positive word



Control Condition:

Negative expression



Control Condition:

Negative word





APPENDIX C

POSITIVE AND NEGATIVE WORDS SELECTED FOR THE *HAPPY AND*  
*ANGRY AND HAPPY AND SAD* EXPERIMENTS.

Positive and negative words selected for the *Happy and Angry* and *Happy and Sad* experiments.

Happy & Angry Experiments

*Positive Words*

Happy

Bliss

Joyful

Merry

Glee

Elated

*Negative Words*

Angry

Wrath

Rage

Livid

Sulk

Furious

Happy & Sad Experiments

*Positive Words*

Happy

Bliss

Joyful

Merry

Glee

Elated

*Negative Words*

Sad

Bleak

Grieve

Sorrow

Mourn

Despair

Table 1

*Reliability Study: The Mean Accuracy of Each Poser for Each Facial Expression*

Expression	Poser			
	Male 1	Male 2	Female 1	Female 2
Happy	100%	100%	100%	100%
Sad	97%	100%	100%	100%
Angry	97%	100%	100%	100%

Table 2

*Experiment 1: The Mean Accuracy of Each Poser for Each Facial Expression*

Poser	Expression	
	Happy	Sad
Male 1	100%	87.5%
Male 2	97%	97.5%
Male 3	100%	100%
Male 4	95%	97.5%
Female 1	97.5%	87.5%
Female 2	97.5%	97.5%
Female 3	100%	97.5%
Female 4	100%	100%
	Happy	Angry
Male 1	100%	95%
Male 2	97%	100%
Male 5	100%	100%
Male 6	100%	93.8%
Female 2	100%	93.8%
Female 5	100%	96.9%
Female 6	96.9%	100%
Female 7	100%	100%

Table 3  
*Number of Subjects excluded per experiment.*

Experiment	Exceeded 2.5 standard deviations: Mean Reaction Time	Exceeded 2.5 standard deviations: Percent Correct	Missed definition of Word	Other
Happy/Sad	1	4	4	0
Happy/Angry	1	3	0	0
Lateralized Happy/Sad	2	3	4	1
Lateralized Happy/Angry	2	2	2	0

Note. Numbers represent how many subjects were excluded per experiment. Missed definition of Word = missed word on Word Test and/or missed  $\geq 50\%$  of a word during an experiment; Other = misunderstood directions.

Table 4

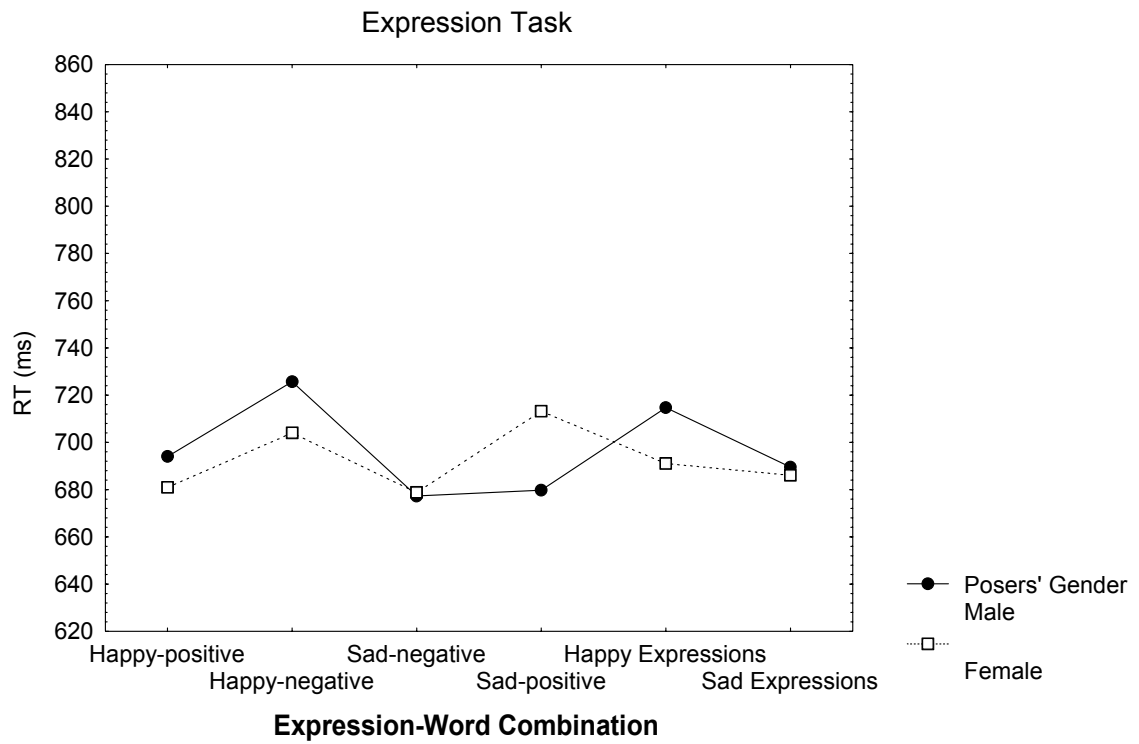
*Mean change of percent correct from the Accuracy Study to the Happy and Sad and Happy and Angry experiments.*

	Posers' Gender	
	Male	Female
<i>Central Happy and Sad</i>		
Happy expression	decrease 5%	decrease 3%
Sad expression	no change	increase 2%
<i>Lateralized Happy and Sad</i>		
Happy expression	decrease 4%	decrease 3%
Sad expression	increase 1%	no change
<i>Central Happy and Angry</i>		
Happy expression	decrease 6%	decrease 4%
Angry expression	decrease 1%	decrease 2%
<i>Lateralized Happy and Angry</i>		
Happy expression	decrease 5%	decrease 3%
Angry expression	no change	decrease 2%

Note. Decrease or increase % = averaged change in mean accuracies from the *Accuracy* experiment to specified experiments.

*Figure 1. Central Happy and Sad experiment: Interaction of Posers' Gender x Expression-Word Combination. Female posers' Sad-positive expression-word combination approached significance from the male posers' Sad-positive expression-word combination,  $p = .05$ .*

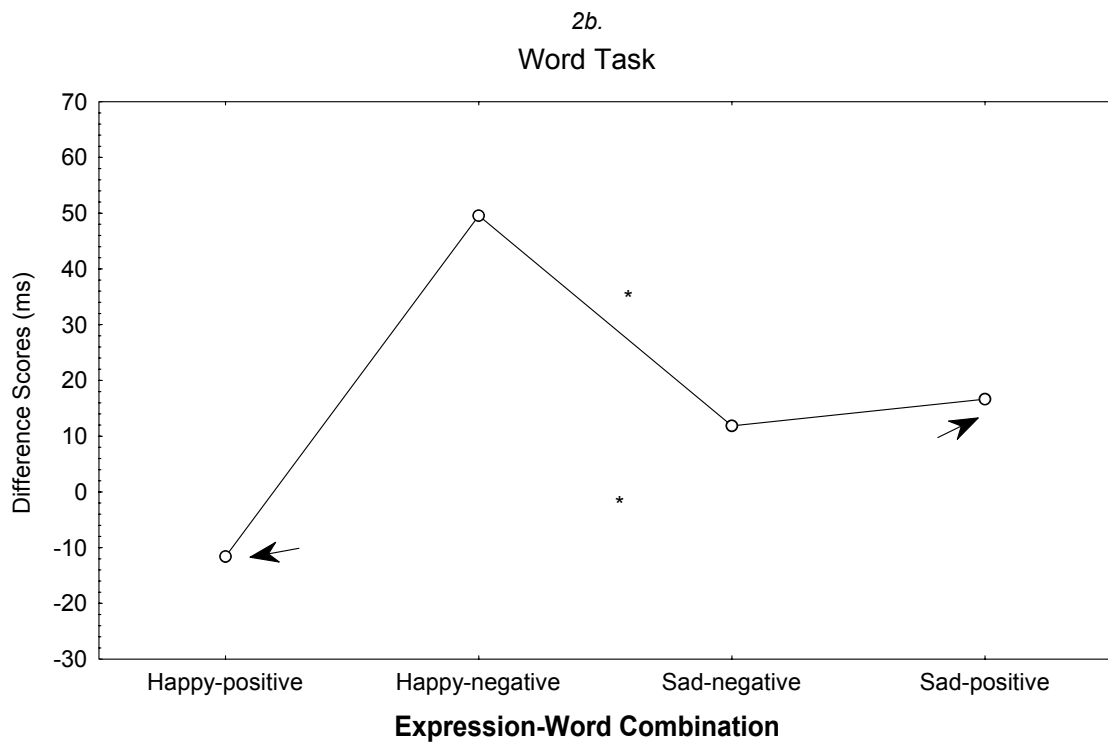
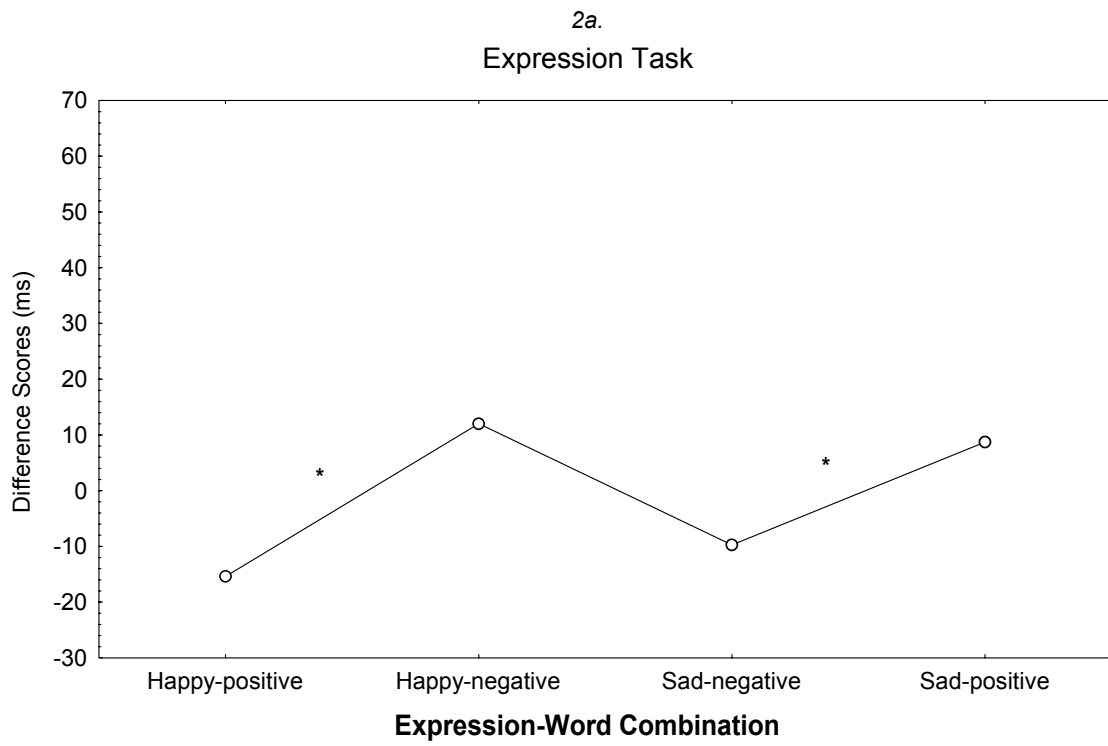
Figure 1.





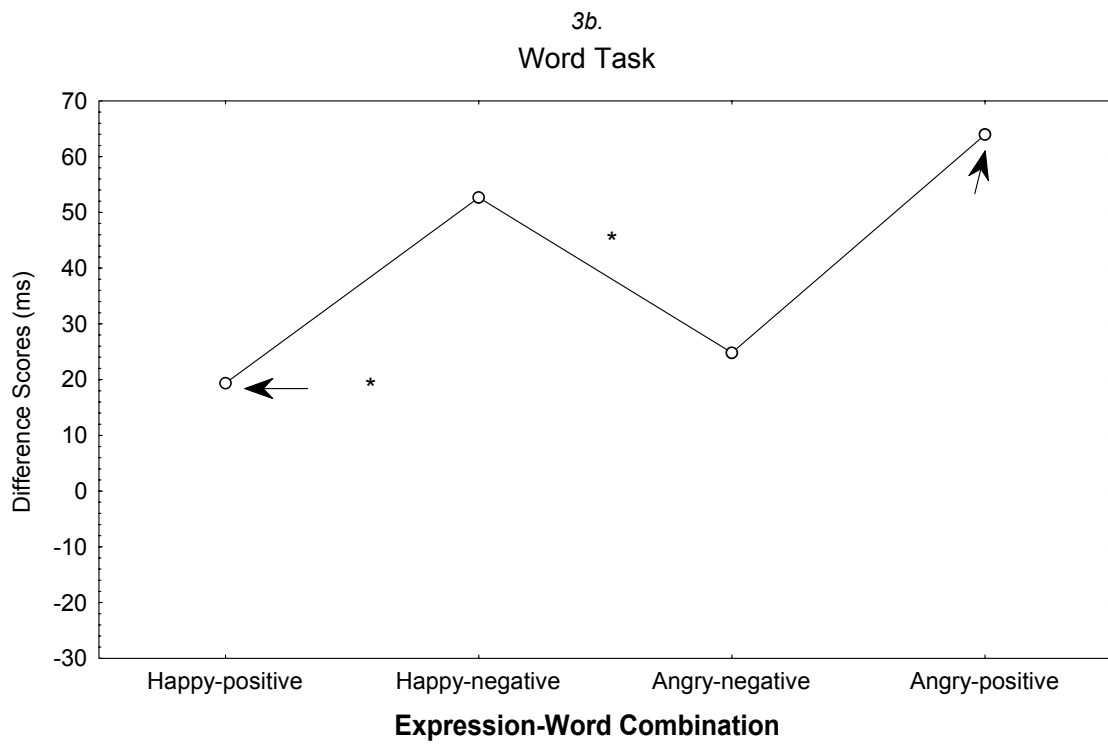
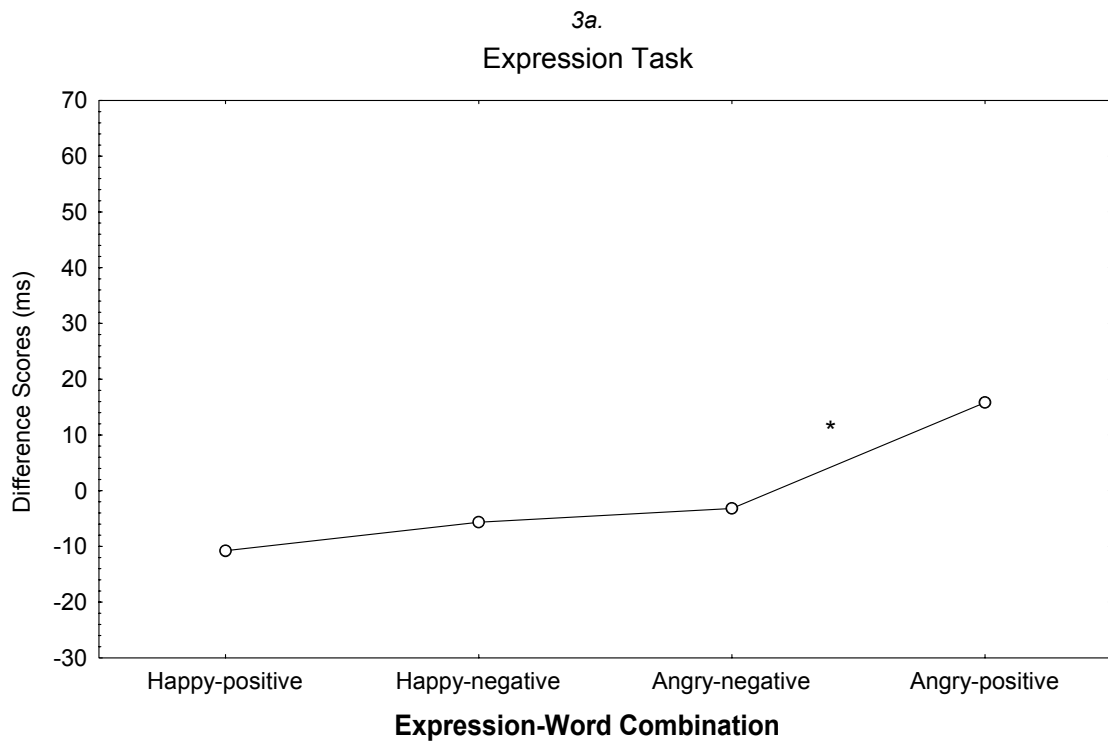
*Figures 2a & 2b. Central Happy and Sad experiment: Expression-Word Combination.* For both tasks, congruent combinations were significantly different from incongruent combinations,  $p < .05$ . Note. \* indicates significance at  $p < .05$ ; \* in between arrows indicates significance at  $p < .05$ .

Figures 2a & 2b.



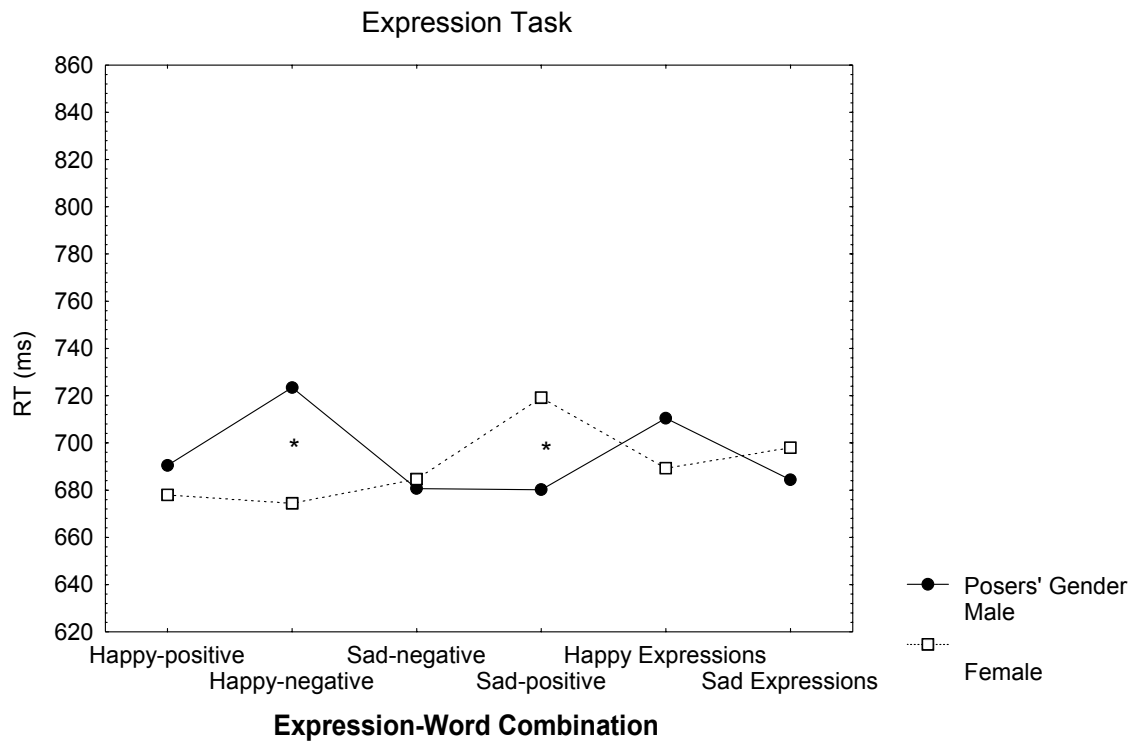
*Figures 3a & 3b. Central Happy and Angry experiment: Expression-Word Combination.* For *Expression*, Angry congruent pair was significantly different from incongruent combination,  $p < .05$ . For *Word*, congruent pairs were significantly different from incongruent pairs,  $p < .05$ . Note. \* indicates significance at  $p < .05$ ; \* in between arrows indicates significance at  $p < .05$ .

Figures 3a & 3b.



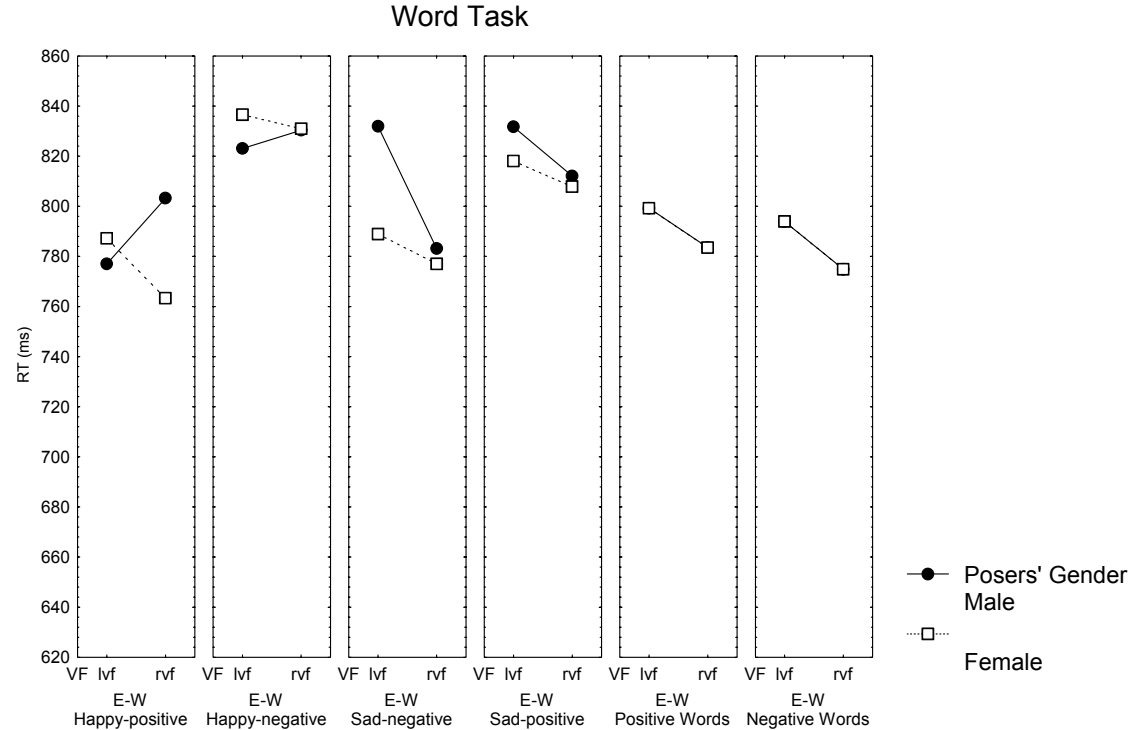
*Figure 4.* Lateralized *Happy and Sad* experiment: Interaction of Posers' Gender x Expression-Word Combination. Male posers' Happy-negative expression-word combination was significantly different from female posers' Happy-negative combination,  $p < .05$ . Female posers' Sad-positive combination was significantly different from male posers' Sad-positive combination,  $p < .05$ . Note. \* indicates significance at  $p < .05$ .

Figure 4



*Figure 5.* Lateralized *Happy and Sad* experiment: Interaction of Posers' Gender x Expression-Word Combination x Visual Field. Post hoc tests did not reveal any interesting significantly different combinations. Note. E-W = Expression-Word Combination; VF = Visual Field; lvf = left visual field; rvf = right visual field.

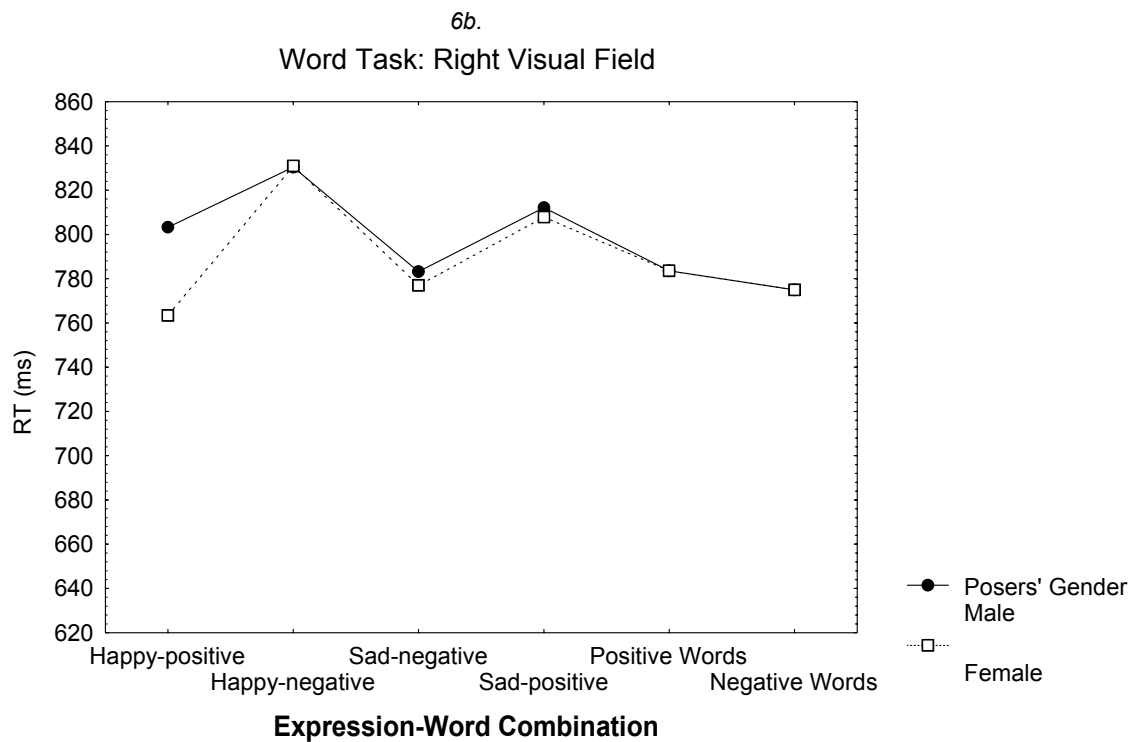
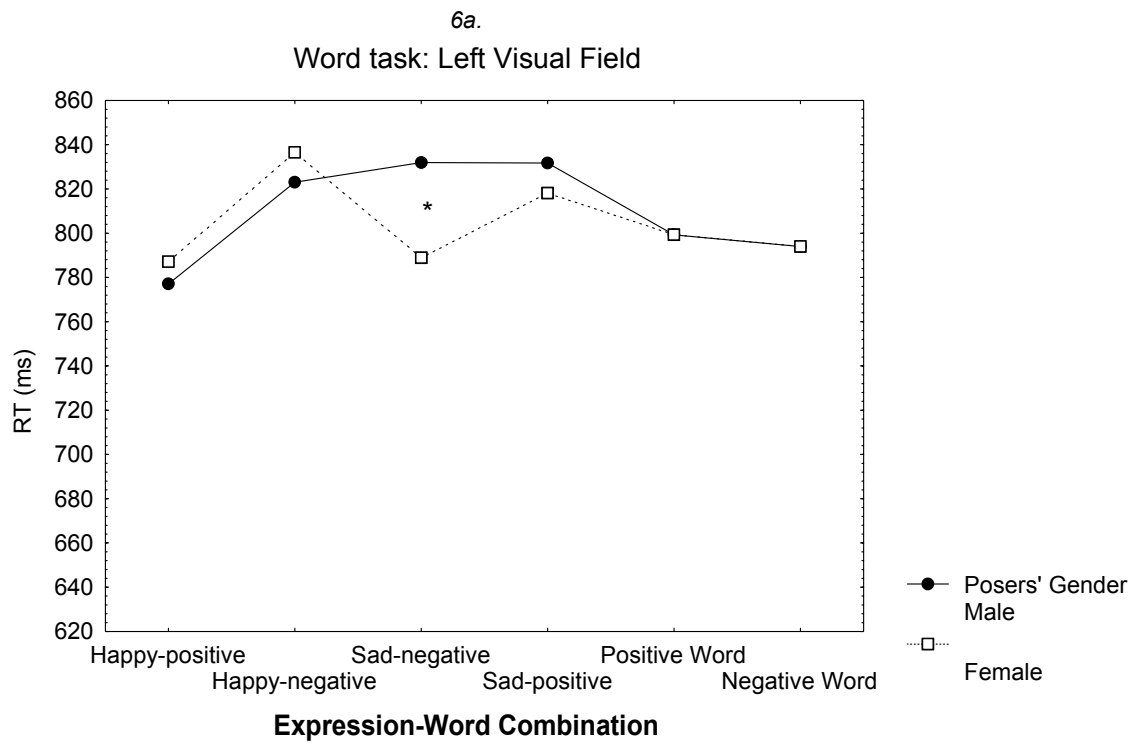
Figure 5.





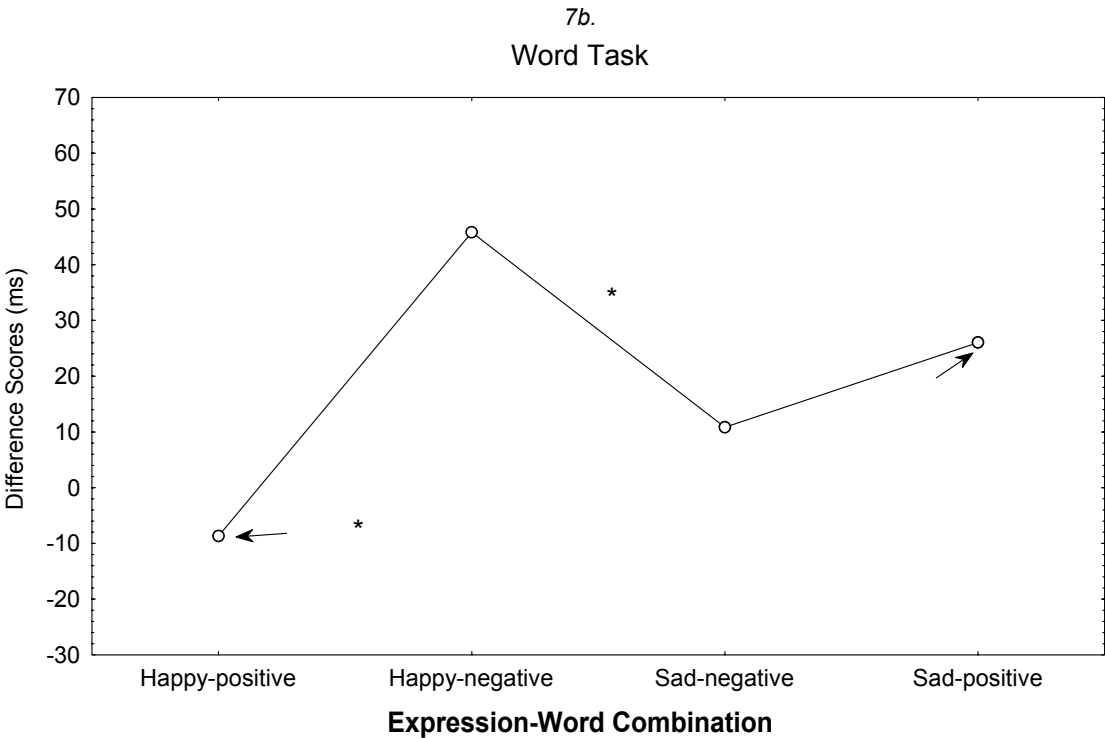
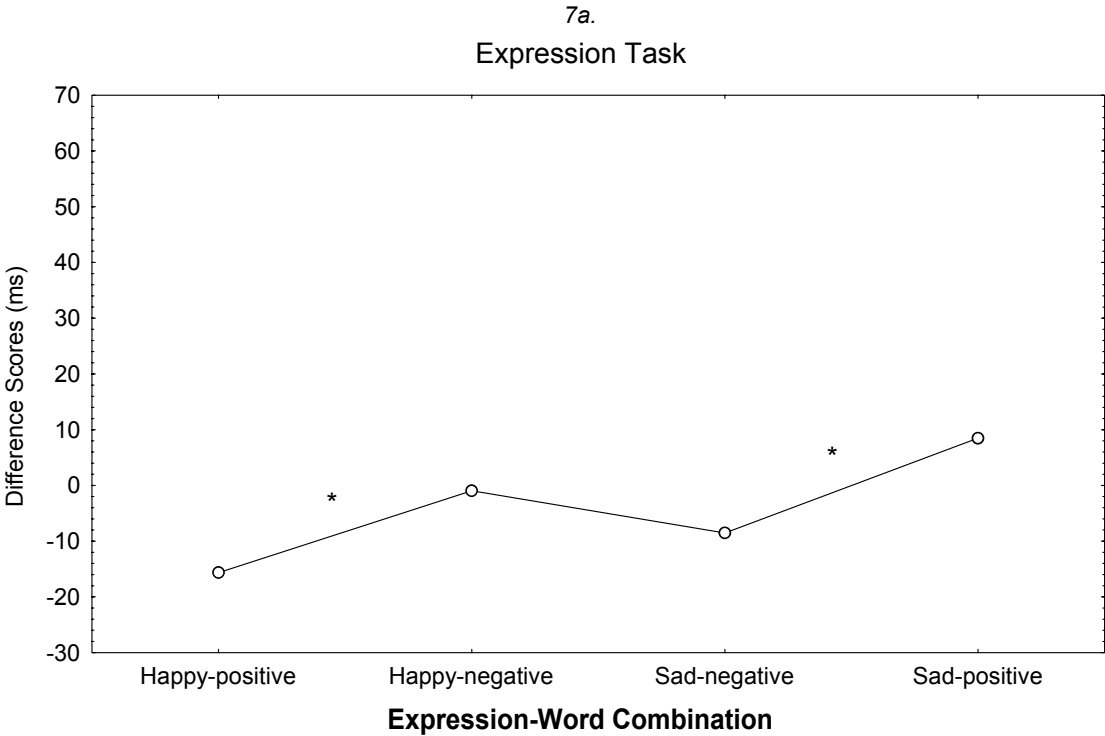
*Figures 6a & 6b.* Lateralized *Happy and Sad* experiment: Word task. In Left Visual Field, male posers' Sad-negative combination was significantly different from female posers' Sad-negative combination,  $p < .05$ ; and male posers' Sad-positive combination was significantly different from male posers' Sad-negative combination,  $p < .05$ . Note. \* indicates significance at  $p < .05$ .

Figures 6a & 6b.



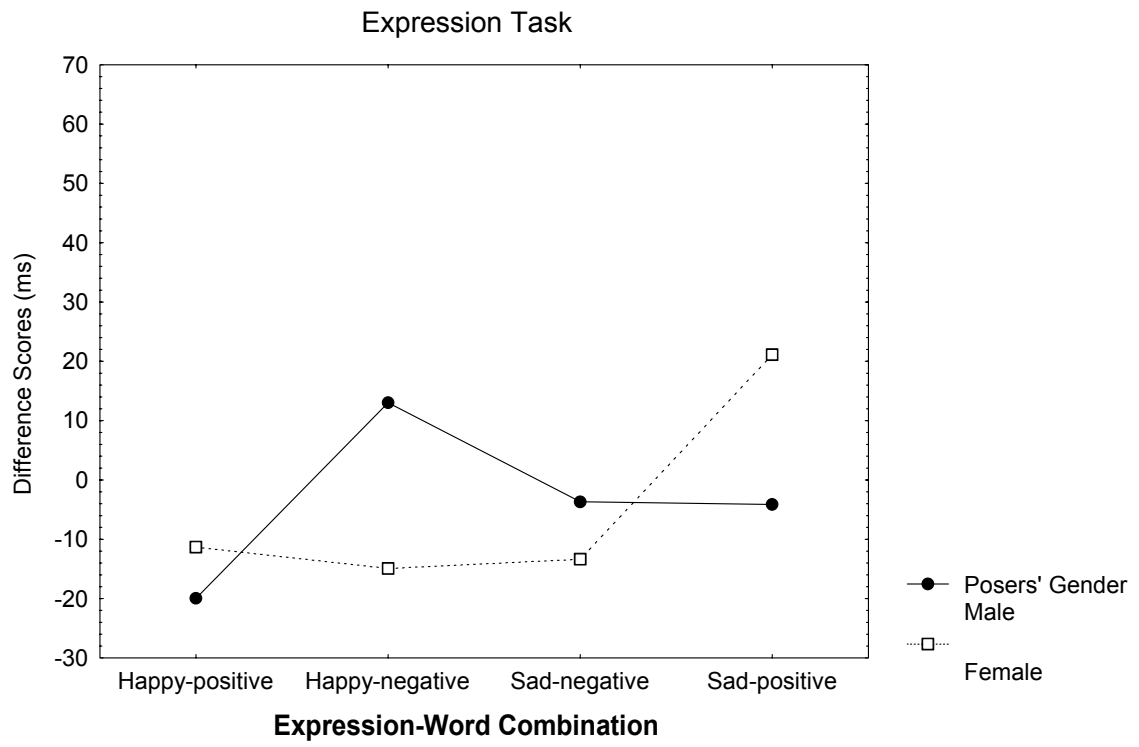
*Figures 7a & 7b.* Lateralized *Happy and Sad* experiment: Expression-Word Combination. For both tasks, congruent combinations were significantly different from incongruent combinations,  $p < .05$ . Note. \* indicates significance at  $p < .05$ ; \* in between arrows indicates significance at  $p < .05$ .

Figures 7a & 7b.



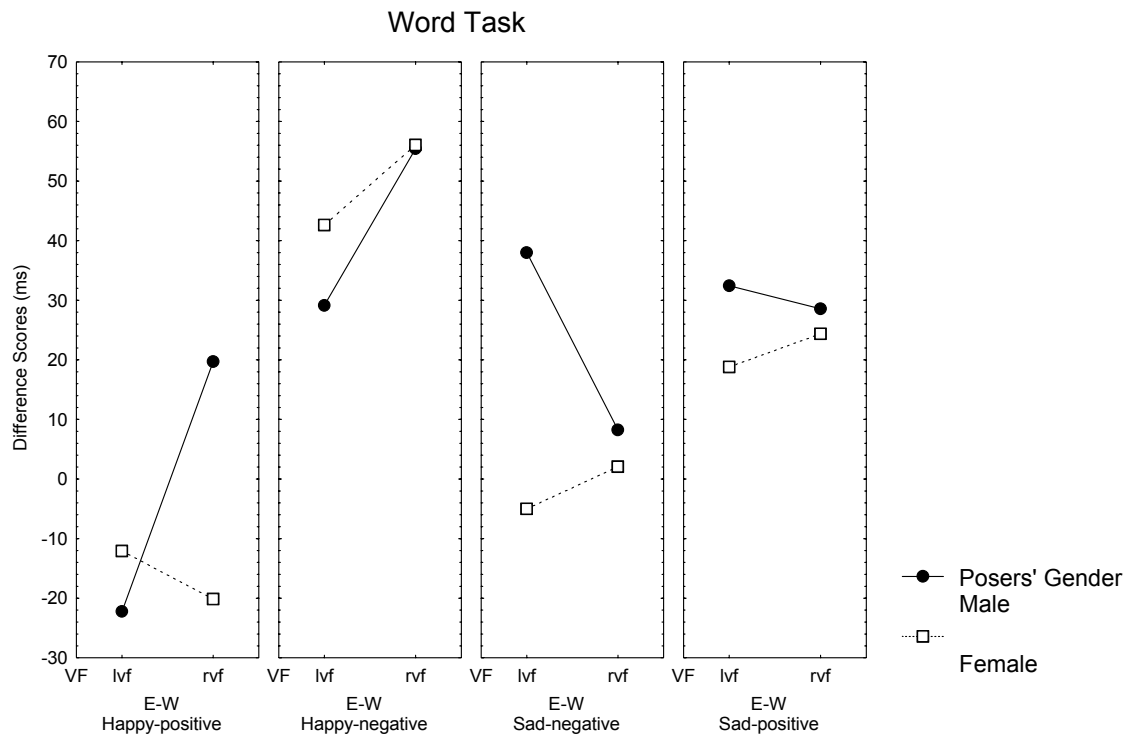
*Figure 8.* Lateralized *Happy and Sad* experiment: Interaction Posers' Gender x Expression-Word Combination. Post hoc tests did not reveal any interesting significantly different combinations.

Figure 8.



*Figure 9.* Lateralized *Happy and Sad* experiment: Interaction Posers' Gender x Expression-Word Combination. Post hoc tests did not reveal any interesting significantly different combinations. Note. E-W = Expression-Word Combination; VF = Visual Field; lvf = left visual field; rvf = right visual field.

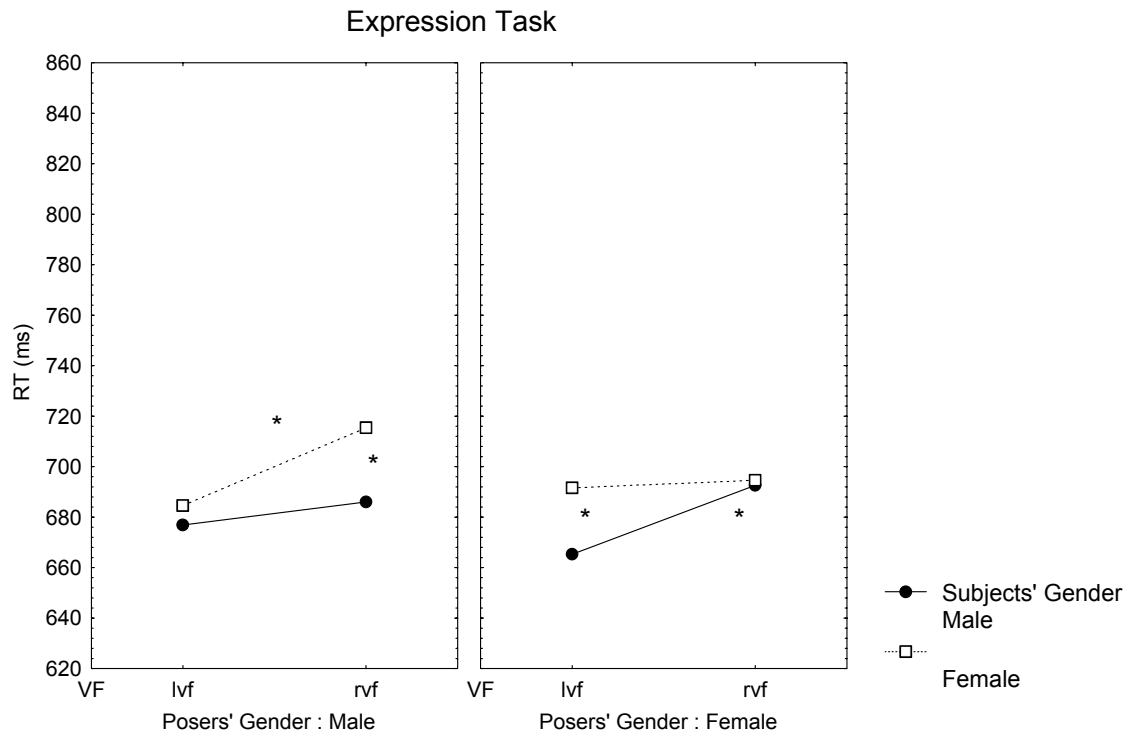
Figure 9.





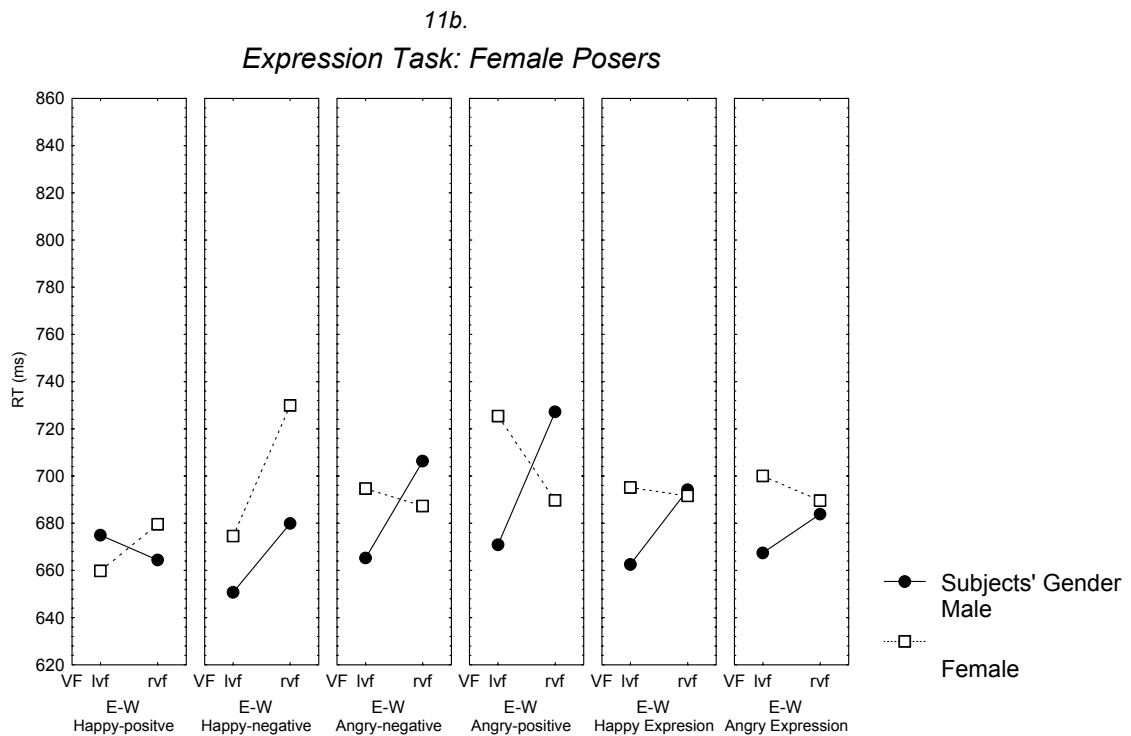
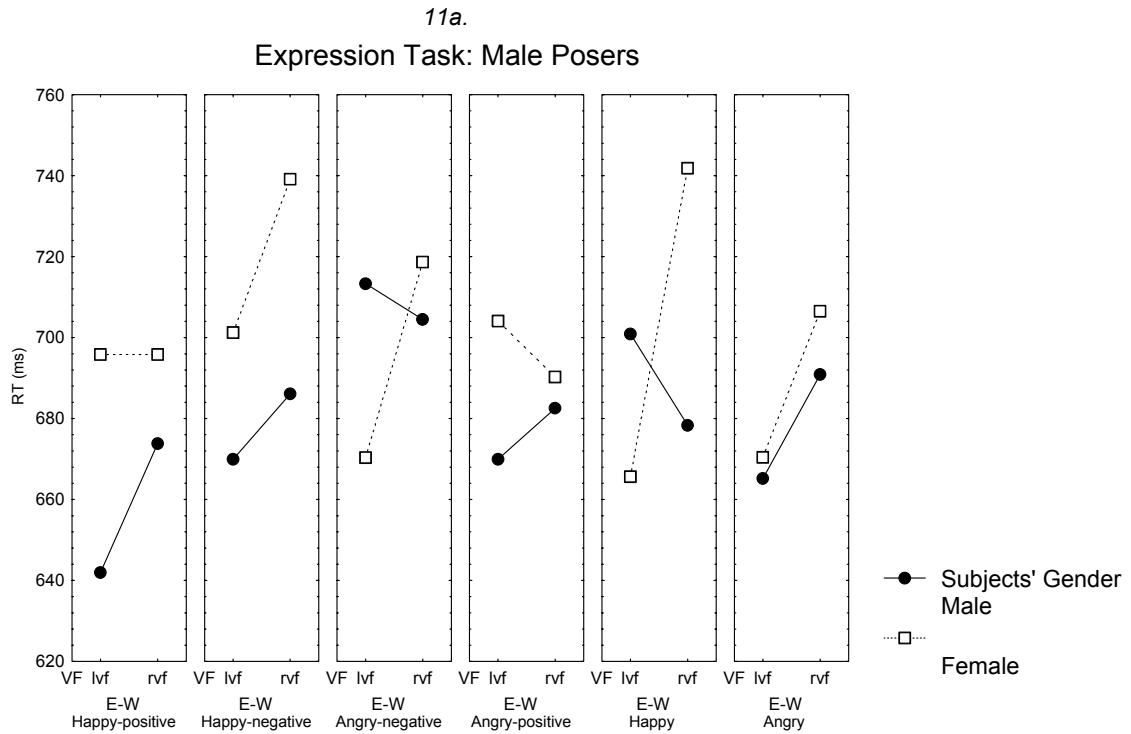
*Figure 10.* Lateralized *Happy and Angry* experiment: Interaction Posers' Gender x Expression-Word Combination x Visual Field. For the male posers, the lvf for female subjects were significantly different from their rvf. And in the rvf, female subjects were significantly different from male subjects. For female posers, male subjects in rvf were significantly different from their lvf. And in the lvf, male subjects were significantly different from female subjects. All were significant at the  $p < .05$ . Note. VF = Visual Field; lvf= left visual field; rvf = right visual field; \* indicates significance at  $p < .05$ .

Figure 10.



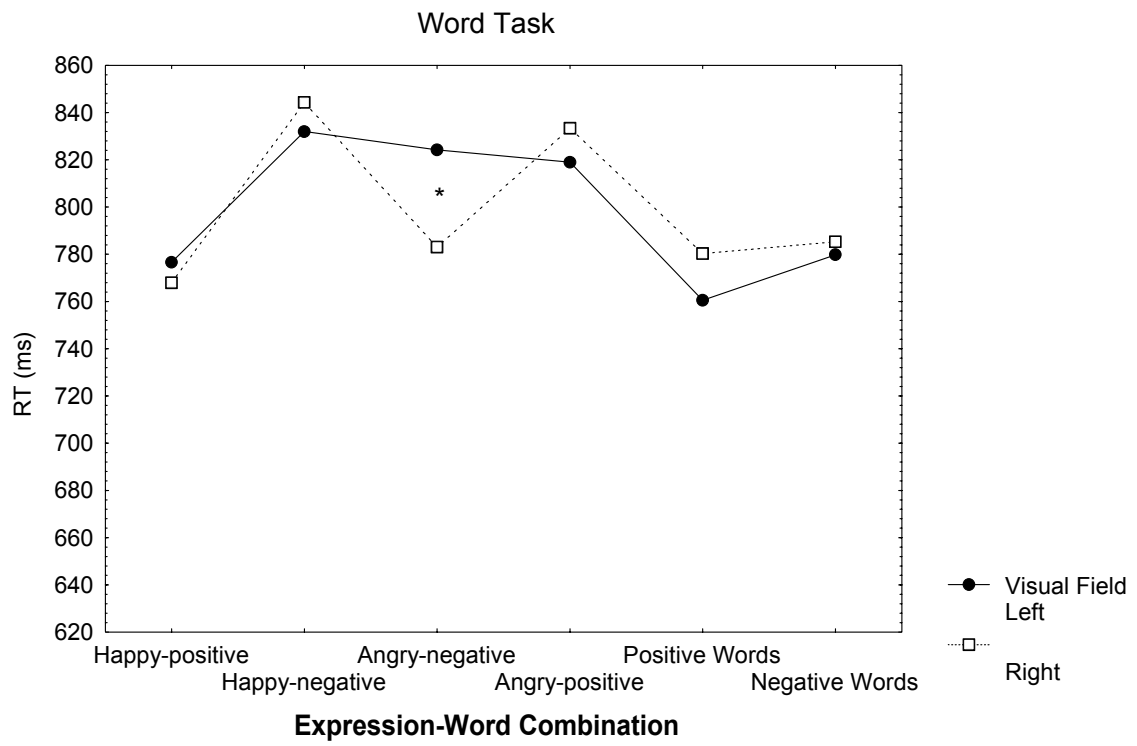
*Figures 11a & 11b.* Lateralized *Happy and Angry* experiment: Interaction Subjects' Gender x Expression-Word Combination x Visual Field per Posers' Gender. Post hoc tests did not reveal any interesting significantly different combinations. Note. E-W: Expression-Word Combination; VF: Visual Field; lvf: left visual field; rvf: right visual field.

Figures 11a & 11b.



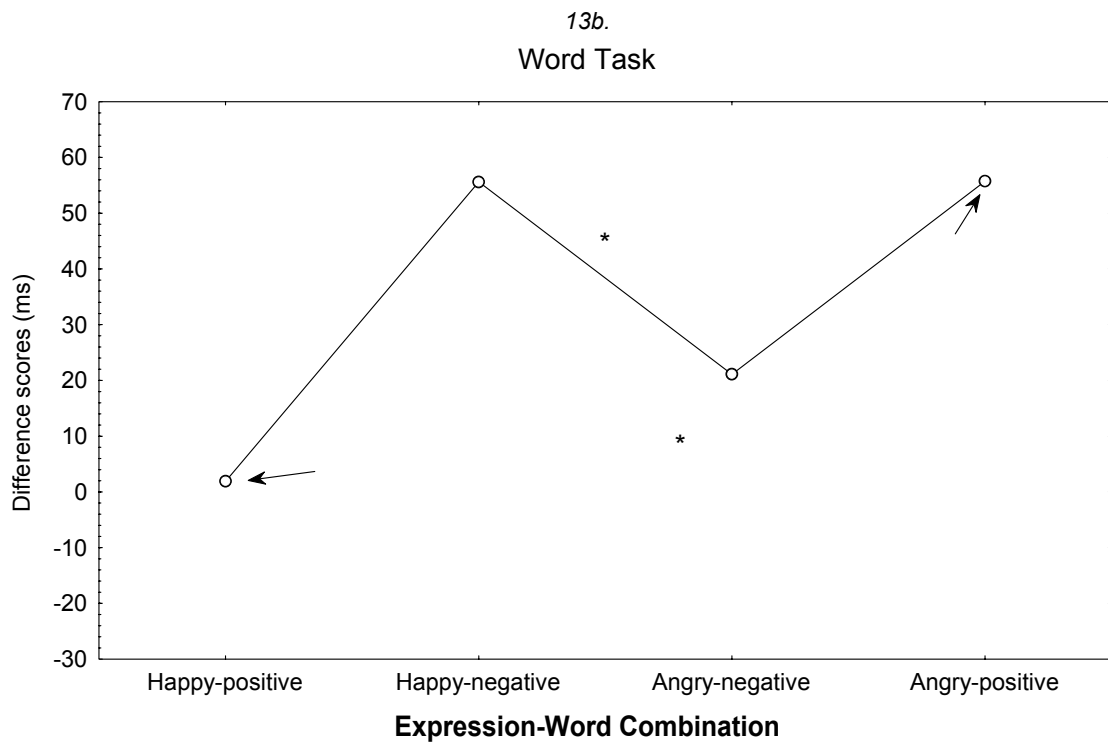
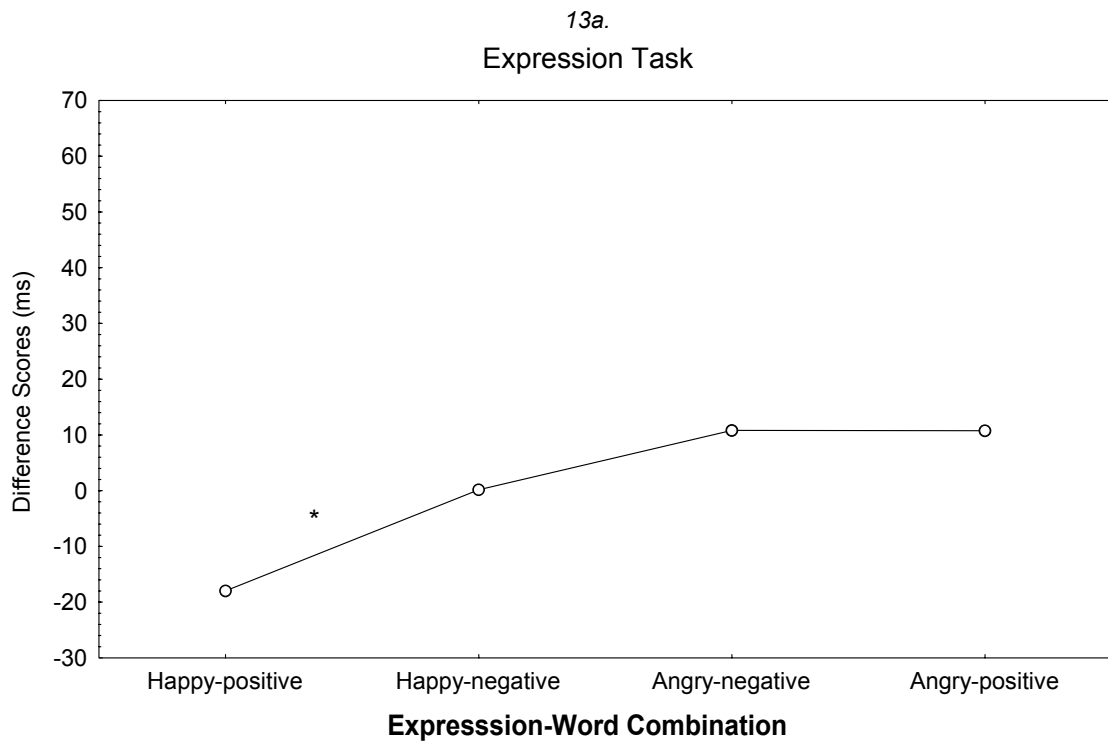
*Figure 12.* Lateralized *Happy and Angry* experiment: Interaction Visual Field x Expression-Word Combination. Angry-negative combination in the left visual field was significantly different from the right visual field,  $p < .05$ . Angry-negative combination in the rvf was significantly different from Angry-positive combination in the rvf,  $p < .05$ . Note. \* indicates significance at  $p < .05$ .

Figure 12.



*Figures 13a & 13b.* Lateralized *Happy and Angry* experiment: Expression-Word Combination. For *Expresision*, Happy-positive combination was significantly different from Happy-negative combination,  $p < .05$ . For *Word*, congruent combinations were significantly different from incongruent combinations,  $p < .05$ . Note. \* indicates significance at  $p < .05$ ; \* in between arrows indicates significance at  $p < .05$ .

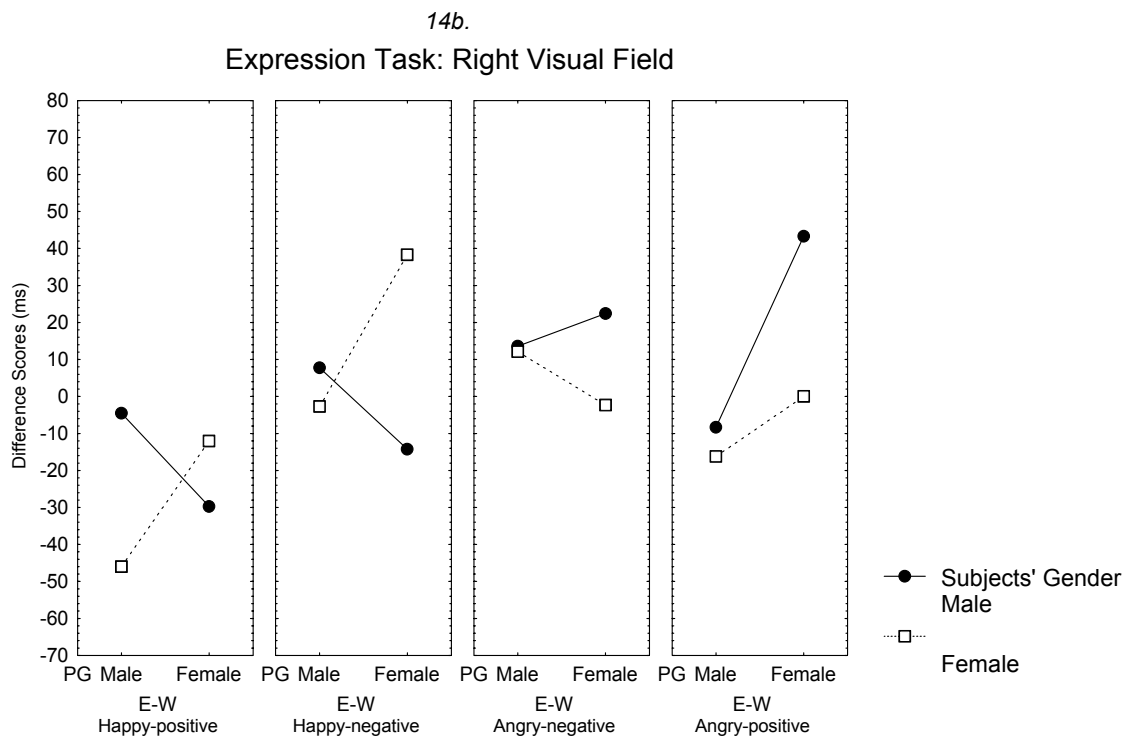
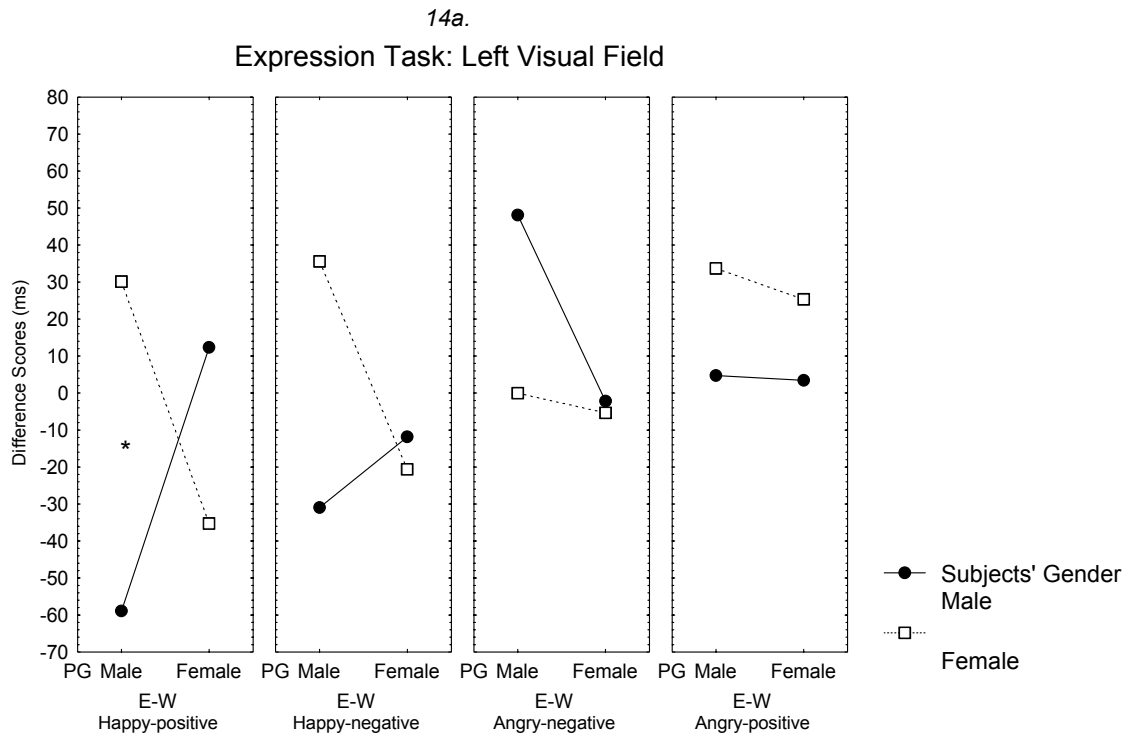
Figures 13a & 13b.





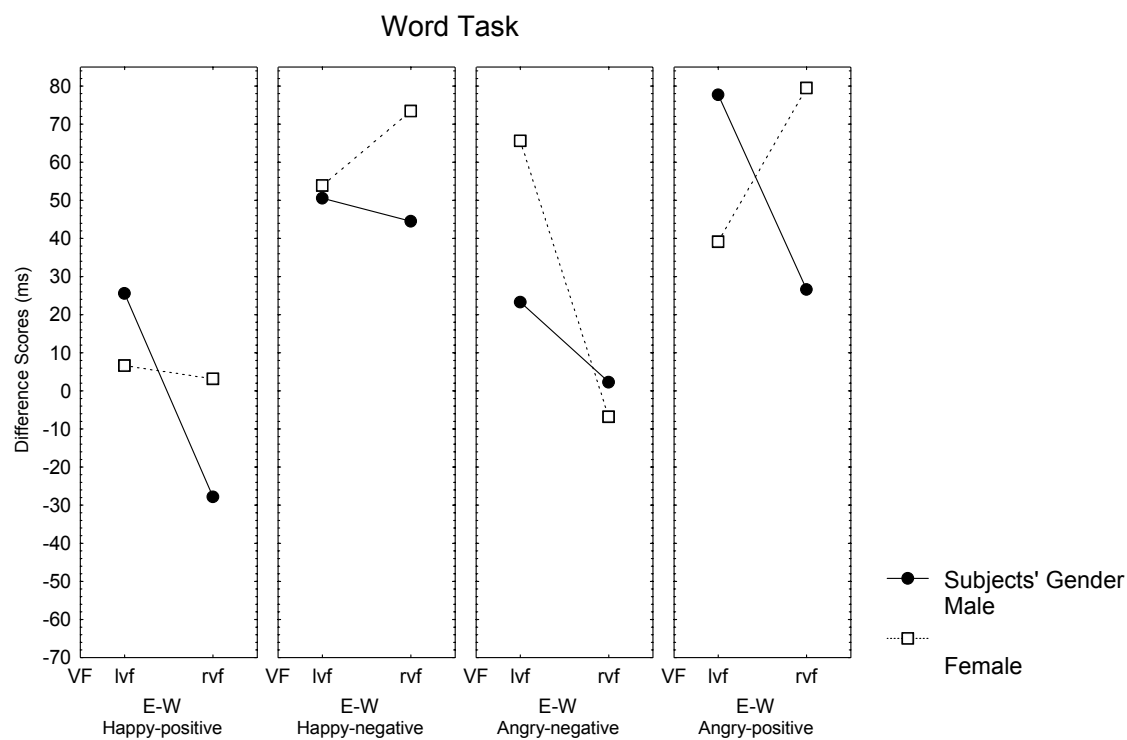
*Figures 14a & 14b.* Interaction Subjects' Gender x Expression-Word Combination x Subjects' Gender x Posers' Gender per Visual Field. Post hoc tests only revealed a significant difference between the male and female posers in the lvf for the pairing of Happy-positive. Note. E-W: Expression-Word Combination; PG: Posers' Gender. \* indicates significance at  $p < .05$ .

Figures 14a & 14b.



*Figure 15.* Interaction Subjects' Gender x Expression-Word Combination x Subjects' Gender x Visual Field. Post hoc tests did not reveal any significantly different paring. Note. E-W: Expression-Word Combination; VF: Visual Field; lvf: left visual field; rvf: right visual field.

Figure 15.



## REFERENCE LIST

- Andrew, R. J. (1963). Evolution of facial expression. *Science*, 142, 1034-1041.
- Banich, M. T., & Belger, A. (1990). Interhemispheric interaction: How do the hemispheres divide and conquer a task? *Cortex*, 26, 77-94.
- Banich, M. T., & Passarotti, A. (1999). *Interhemispheric interaction aids task performance under conditions of selective attention*. Manuscript submitted for publication.
- Bargh, J. A. (1989). Conditional automaticity: Varieties of automatic influence in social perception and cognition. In J. S. Uleman & J. A. Bargh (Eds.), *Unintended thought* (pp. 3-51). New York: Guilford.
- Bargh, J. A., & Pietromonaco, P. (1982). Automatic information processing and social perception: The influence of trait information presented outside of conscious awareness on impression formation. *Journal of Personality and Social Psychology*, 43, 437-449.
- Barreara, M. E., & Maurer, D. (1981). The perception of facial expressions by the three-month-old infant. *Child Development*, 52, 203-206.
- Bowers, D., & Heilman, K. M. (1984). Dissociation between the processing of affective and nonaffective faces: A case study. *Journal of Clinical Neuropsychology*, 6, 367-379.
- Bradley, B. P., Mogg, K., Millar, N., & Neil, H. (2000). Covert and overt orienting of

- attention to emotional faces in anxiety. *Cognition and Emotion*, 14, 789-808.
- Bruyer, R. (1986). *The neuropsychology of face perception and facial expression*. Hillsdale, NJ: Lawrence Erlbaum.
- Bryson, S. E., McLaren, J., Wadden, N. P., and MacLean, M. (1991). Differential asymmetries for positive and negative emotion: Hemisphere or stimulus effects? *Cortex*, 27, 359-365.
- Bugental, D. B., Blue, J., & Lewis, J. (1990). Caregiver beliefs and dysphoric affect directed to difficult children. *Developmental Psychology*, 26, 631-638.
- Burton, L. A., & Levy, J. (1989). Sex Differences in the lateralized processing of facial emotion. *Brain and Cognition*, 11, 210-228.
- Carroll, J. B., Davies, P., & Richman, B. (1971). *Word frequency book*. New York: American Heritage.
- Cattell, J. M. (1886). The time it takes to see and name objects. *Mind*, 11, 63-65.
- Clore, G. L., Ortony, A., & Foss, M. A. (1987). The psychological foundations of the affective lexicon. *Journal of Personality and Social Psychology*, 53, 751-766.
- Christianson, S. A., Saisa, J., & Sifvenius, H. (1995). The right hemisphere recognizes the bad guys. *Cognition and Emotion*, 9, 309-324.
- Darwin, C. (1904), (First ed., 1872). *The first expression of the emotions in man and animals*. London: John Murray.
- David, A. S. (1991). Stroop effects within and between the cerebral hemispheres: Studies in normals and acahosals. *Neuropsychologia*, 30, 161-175.

- Dawkins, T., & Furnham, E. (1989). The color naming of emotional words. *British Journal of Psychology*, 80, 383-389.
- De Houwer, J., & Hermans, D. (1994). Differences in the affective processing of words and pictures. *Cognition and Emotion*, 8, 1-20.
- Dimberg, U. (1997). Psychophysiological reactions to facial expressions. In U. Segerstrale, & P. Molnar (Eds.), *Nonverbal Communication: Where Nature Meets Culture*. (pp. 47-60). New Jersey: Lawrence Erlbaum Associates.
- Dunbar, K., & MacLeod, C. M. (1984). A horse race of a different color: Stroop interference patterns with transformed words. *Journal of Experimental Psychology: Human Perception and Performance*, 10, 622-639.
- Dyer, F. N. (1971). The duration of word meaning responses: Stroop interference for different preexposures of the word. *Psychonomic Science*, 25, 229-231.
- Dyer, F. N. (1973). Interference and facilitation for color naming with separate bilateral presentations of the word and color. *Journal of Experimental Psychology*, 99, 314-317.
- Dyer, F. N., & Severance, L. J. (1973). Stroop interference with successive presentations of separate incongruent words and colors. *Journal of Experimental Psychology*, 98, 438-439.
- Ekman, P. (1972). *Universal and cultural differences in facial expressions of emotion*. In Nebraska Symposium on Motivation. J. Coles (Ed.), University of Nebraska: Lincoln, Nebraska.

- Ekman, P. (1977). Biological and cultural contributions to body and facial movement. In J. Backing (Ed.), *Anthropology of the Body* (pp. 34-84). London: Academic Press.
- Ekman, P. (1999). Basic Emotions. In T. Dalgleish and M. J. Power (Eds.), *Handbook of Cognition and Emotion* (pp. 45-60). New York: John Wiley & Sons.
- Ekman, P. & Friesen, W. V. (1971). Constants across cultures in the face and emotion. *Journal of Personal Social Psychology*, 17, 124-129.
- Ekman, P., & Friesen, W. V. (1976). Measuring facial movement. *Journal of Environmental Psychology and Nonverbal Behavior*, 1, 56-75.
- Ekman, P., Friesen, W. V., and Tomkins, S. S. (1971). Facial affect scoring technique: A first validity study. *Semiotica*, 3, 37-58.
- Ekman, P., Sorenson, E. R., & Friesen, W. V. (1969). Pan-cultural elements in facial displays of emotion. *Science*, 164, 86-88.
- Erwin, R. J., Gur, R. C., Gur, R. E., Skolnick, B., Mawhinney-Hee, M., & Smailis, J. (1992). Facial emotion discrimination: I. Task construction and behavioral findings in normal subjects. *Psychiatry Research*, 42, 231-240.
- Esteves, F., & Ohman, A. (1993). Masking the face: Recognition of emotional facial expressions as a function of parameters of backward masking. *Scandinavian Journal of Psychology*, 34, 1-18.
- Eysenck, M. W. (1992). *Anxiety: The Cognitive Perspective*. Hillsdale, NJ: Erlbaum.
- Fabes, R. A., & Martin, C. L. (1991). Gender and age stereotypes of emotionality.



- Personality and Social Psychology Bulletin*, 17, 532-540.
- Fehr, B., & Russell, J. A. (1984). Concept of emotion viewed from a prototype perspective. *Journal of Experimental Psychology: General*, 113, 464-486.
- Gainotti, G. (1972). Emotional behavior and hemispheric side of lesion. *Cortex*, 8, 41-55.
- Gates, G. S. (1923). An experimental study of the growth of social perception. *Journal of Educational Psychology*, 14, 449-461.
- Gatti, S. V., & Egeth, H. E. (1978). Failure of spatial selectivity in vision. *Bulletin of the Psychonomic Society*, 11, 181-184.
- Gilboa-Schechtman, E., Foa, E. B., & Amir, N. (1999). Attentional biases for facial expressions in social phobia: The face-in-the-crowd paradigm. *Cognition and Emotion*, 13, 305-318.
- Glaser, W. R., & Dungelhoff, F.J. (1984). The time course of picture-word interference. *Journal of Experimental Psychology: Human Perception and Performance*, 10, 640-654.
- Glaser, M. O., & Glaser, W. R. (1982). Time course analysis of the Stroop phenomenon. *Journal of Experimental Psychology: Human Perception and Performance*, 8, 875-894.
- Glaser, W. R., & Gaser, M. O. (1989). Context effects in Stroop-like word and picture processing. *Journal of Experimental Psychology: General*, 118, 13-42.
- Glass, A. L., Holyoak, K. J., & Santa, J. L. (1979). *Cognition*. Reading, MA:

Addison-Wesley.

Goldstein, K. (1952). The effects of brain damage on the personality. *Psychiatry*, 15, 245-260.

Greenwald, A. G., Klinger, M. R., & Lui, T. J. (1989). Unconscious processing of dichoptically masked words. *Memory and Cognition*, 17, 35-47.

Hansen, C. H., & Hansen, R. D. (1994). Automatic emotion: Attention and facial efference. In P. M. Niedenthal & S. Kitayama (Eds.), *The Heart's Eye: Emotional Influences in Perception and Attention* (pp. 217-243). New York :Academic Press.

Hartlage, S., Alloy, L. B., Vazquez, C., & Dykman, B. (1993). Automatic and effortful processing in depression. *Psychological Bulletin*, 113, 247-278.

Hentschel, U. (1973). Two new interference tests compared to the Stroop Color-Word Test. *Psychological Research Bulletin*, 13, 1-24.

Herrenkol, R., Herrenkol, E., Egolf, B., & Wu, P. (1991). The developmental consequences of child abuse. In R. Starr & D. Wolfe (Eds. ), *The effects of child abuse and neglect* (pp. 57-81). New York: Guilford Press.

Hock, H. W., & Egeth, H. E. (1970). Verbal interference with encoding in a perceptual classification task. *Journal of Experimental Psychology*, 83, 299-303.

Hooff van, J. A. (1971). *Aspecten van het sociale gedrag en de communication bij humane en hogere niet-humane primaten* (Aspects of social

- behavior and communication in human and other higher primates). Netherlands: Bronder.
- Hooff van, J. A. (1997). The social function of “smile” and “laughter”: Variations across primate species and societies. In J. Segerstrale, & P. Molner (Eds.), *Nonverbal communication: Where nature meets culture* (pp. 171-190). Mahwah, New Jersey: Lawrence Erlbaum Associates.
- Hunt, K. P., & Hodge, M. H. (1971). Category-item frequency and category-name meaningfulness: Taxonomic norms for 83 categories. *Psychonomic Monograph Supplements*, 4 (6, Whole No. 54).
- Hunt, E., & Lansman, M. (1986). Unified model of attention and problem solving. *Psychological Review*, 93, 446-461.
- Hyde, J. S. (1984). How large are gender differences in aggression? A developmental meta-analysis. *Developmental Psychology*, 20, 722-736.
- Isen, A. M., & Diamond, G. A. (1989). Affect and automatically. In J. S. Uleman & J. A. Bargh (Eds.), *Unintended thought* (pp. 124-152). New York: Guilford.
- Izard, C. E. (1971). *The face of emotion*. New York: Appleton Century-Crofts.
- Jansari, A., Tranel, D., & Adolphs, R. (2000). A valence-specific lateral bias for discriminating emotional facial expressions in free field. *Cognition and Emotion*, 14, 341-353.
- Johnston-Laird, P. N., & Oatley, K. (1989). The language of emotions: An analysis of a semantic field. *Cognition and Emotion*, 3, 81-123.

- Johnston-Laird, P. N., & Oatley, K. (1992). Basic emotions: A cognitive science approach to function, folk theory and empirical study. *Cognition and Emotion*, 6, 201-223.
- Julesz, B. (1984). A brief outline of the texture theory of human vision. *Trends in Neuroscience*, 7, 41-45.
- Kahneman, D., & Chajczyk, D. (1983). Tests of the automaticity of reading: Dilution of Stroop effects by color-irrelevant stimuli. *Journal of Experimental Psychology: Human Perception and Performance*, 9, 497-509.
- Kihlstrom, J. F. (1987). The cognitive unconscious. *Science*, 237, 1445-1452.
- Kirouac, G., & Dore, F.Y. (1982). Identification des expressions faciales émotionnelles par un échantillon Québécois Francophone. *International Journal of Psychology*, 17, 1-7.
- Kirouac, G., & Dore, F.Y. (1983). Accuracy and latency of judgment of facial expressions of emotions. *Perceptual and motor skills*, 57, 683-686.
- Kirouac, G., & Dore, F.Y. (1984). Judgment of facial expressions of emotions as a function of exposure time. *Perceptual and motor skills*, 59, 147-150.
- Kirouac, G., & Dore, F.Y. (1985). Accuracy of the judgment of facial expressions of emotions as a function of sex and level of education. *Journal of Nonverbal Behavior*, 9, 3-7.
- Kitayama, S. (1990). Impairment of perception by positive and negative affect. *Cognition and Emotion*, 5, 255-274.

- Kuchuk, A., Vibbert, M., Y Bornstein, M. H. (1986). The perception of smiling and its experimental correlates in 3-month-old infants. *Child Development, 57*, 1054-1061.
- LaBarbera, J. D., Izard, C. E., Nietze, P., & Parisi, S. A. (1976). Four- and six-month-old infants: Visual responses to joy, anger, and neutral expressions. *Child Development, 57*, 535-538.
- Lachman, R., Lachman, J.L., & Butterfield, E. C. (1979). *Cognitive psychology and information processing: An introduction*. Hillsdale, NJ: Erlbaum.
- LeDoux, J. E. (1991). Emotion and the brain. *Journal of NIH research, 3*, 49-51.
- Ley, R. G., & Bryden, M. P. (1979). Hemispheric differences in processing emotions and faces. *Brain and Language, 7*, 127-138.
- Logan, G. D. (1980). Attention and automaticity in stroop and priming tasks: Theory and data. *Cognitive Psychology, 12*, 523-553.
- Logan, G. D. (1985). Skill and automaticity: relations, implications, and future directions. *Canadian Journal of Psychology, 39*, 367-386.
- Logan, G. D. (1989). Automaticity and cognitive control. In J. S. Uleman & J. A. Bargh (Eds.), *Unintended thoughts* (pp. 52-74). New York: Guilford Press.
- MacLeod, C. M. (1991). Half a century of research on the Stroop Effect: An integrative review. *Psychological Bulletin, 109*, 163-203.
- MacLeod, C. M., & Dunbar, K. (1988). Training and Stroop-like interference: Evidence

- for a continuum of automaticity. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 14, 126-135.
- Mandal, M. K., & Palchoudhury, S. (1985). Perceptual skill in decoding facial affect. *Perceptual and Motor Skills*, 60, 96-98.
- Mathews, G., Pitcaithly, D., & Mann, R. L. (1995). Mood, neuroticism, and the encoding of affective words. *Cognitive Therapy and Research*, 19, 563-587.
- Mathews, G., & Wells, A. (1999). The cognitive science of attention and emotion. In T. Dalgleish and M. J. Power (Eds.), *Handbook of Cognition and Emotion* (pp. 171-192), New York: John Wiley & Sons.
- Michalson, L., & Lewis, M. (1985). What do children know about emotions and when do they know it? In M. Lewis and L. A. Rosenablum (Eds.), *The Socialization of Emotions* (pp. 117-139). New York: Plenum Press.
- Mogg, K., & Bradley, B. R. (1998). *Orienting of attention to threatening facial expressions presented under conditions of restricted awareness*. Manuscript submitted for publication.
- Mogg, K., & Bradley, B. R. (1999). Selective attention and anxiety: A cognitive-motivational perspective. In T. Dalgleish and M. J. Power (Eds.), *Handbook of Cognition and Emotion* (pp. 145-170). New York: John Wiley & Sons.
- Mogg, K., Mathews, A., & Wienman, J. (1989). Selective processing of threat cues in clinical anxiety states: A replication. *Behaviour Research and Therapy*, 27, 317-323.

- Nelson, C. A., & Dolgin, K. (1983). Hemispheric asymmetries in processing emotional expressions. *Child Development*, 56, 58-61.
- Nelson, C. A., Morse, P. A., & Leavitt, L. A. (1979). Recognition of facial expressions by seven-month-old infants. *Child Development*, 50, 1239-124.
- Ogawa, T., & Suzuki, N. (1999). Response differentiation to facial expression of emotion as increasing exposure duration. *Perceptual and Motor Skills*, 89, 557-563.
- Ohman, A. (1983). The orienting response during Pavlovian conditioning (pp. 315-369). In D. A. T. Siddle (Ed.), *Orienting and Habituation: Perspectives in Human Research*. Chishcester: Wiley.
- Ohman, A. (1986). Face the beast and fear the face: Animal and social fears as prototypes for evolutionary analyses of emotion. *Psychophysiology*, 23, 123-145.
- Ohman, A. (1992). Orienting and attention: Preferred preattentive processing of potentially phobic stimuli. In B. A. Campbell, R. Richardson & H. Haynes (Eds.), *Attention and information processing in infants and adults: Perspectives from human and animal research*. Hillsdale, NJ: Erlbaum.
- Oldfield, R. C. (1971). The Assessment and Analysis of Handedness: The Edinburgh Inventory. *Neuropsychologia*, 9, 97-113.
- Peters, M. (1995). Handedness and its relation to other indices of cerebral lateralization. In R. J. Davidson and K. Hugdahl (Eds.), *Brain Asymmetry* (pp. 183-214). England. MIT Press.

- Plant, E. A., Hyde, J. S., Keltner, D., & Devine, P. D. (2000). The gender stereotyping of emotions. *Psychology of Women Quarterly*, 24, 81-92.
- Pollak, S. D., Cicchetti, D., Hornnug, K., & Reed, A. (2000). Recognizing emotion in faces: Developmental effects of child abuse and neglect. *Developmental Psychology*, 36, 679-688.
- Posnansky, C. J., & Rayner, K. (1977). Visual-features and response components in a picture-word interference task with beginning and skilled readers. *Journal of Experimental Child Psychology*, 24, 440-460.
- Posner, M. I., & Snyder, C. R. (1975). Attention and cognitive control. In R. L. Solso (Ed.), *Information processing and cognition, The Loyola Symposium* (pp. 55-85). Hilldale, N. J.: Lawrence Erlban Associates.
- Pratto, F., & John, O. P. (1991). Automatic vigilance: The attention-grabbing power of negative social information. *Journal of Personality and Social Psychology*, 61, 380-391.
- Purcell, D. G., Stewart, A. L., & Skov, R. B. (1996). It takes a confounded face to pop out of a crowd. *Perception*, 25, 1091-1108.
- Pylyshyn, A. W. (1984). *Computation and Cognition: Toward a Foundation for Cognitive Science*. Cambridge, Am: MIT Press.
- Rayner, K., & Posnanski, C. J. (1978). Stages of processing in word identification. *Journal of Experimental Psychology: General*, 107, 64-80.
- Reichenbach, L., & Masters, J. C. (1983). Children's use of expressive and contextual



- cues in judgments of emotion. *Child Development*, 54, 993-1004.
- Reuter-Lorenz, P., & Davidson, R.J. (1981). Differential contributions of the two cerebral hemispheres to the perception of happy and sad faces. *Neuropsychologia*, 19, 609-613.
- Rhodes, G. (1985). Lateralized processes in face recognition. *British Journal of Psychology*, 76, 249-271.
- Rogosch, F. A., Cicchetti, D., & Aber, J. L. (1995). The role of child maltreatment in early deviations in cognitive and affective processing abilities and later peer relationship problems. *Developmental and Psychopathology*, 7, 591-609.
- Rosinski, R. R. (1977). Picture-word interference is semantically based. *Child Development*, 48, 643-647.
- Rosinski, R. R., Golinkoff, R. M., & Kukish, K. S. (1975). Automatic semantic processing in a picture-word interference task. *Child Development*, 46, 247-253.
- Ross, E. D. (1981). The aprosodias: functional-anatomical organization of the affective components of language in the right hemisphere. *Archives of Neurology*, 38, 51-569.
- Rossik, G. F., & Rosadini, G. (1967). Experimental analysis of cerebral dominance in man. In C. H. Milidan and F. L. Darley (Eds.), *Brain mechanisms underlying speech and language* (pp. 167-184). New York: Grune & Stratton, Inc.
- Rotter, N. G., & Rotter, G. S. (1988). Sex differences in the encoding and decoding of negative facial emotions. *Journal of Nonverbal Behavior*, 12, 139-148.

- Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*, 39, 1161-1178.
- Schneider, W., & Shiffrin, R. M. (1977). Controlled and automatic human information processing: I. Detection, search, and attention. *Psychological Review*, 84, 1-66.
- Schwartz, G., Izard, C., & Ansul, S. (1985). The 5-month-olds ability to discriminate facial expressions of emotions. *Infant Behaviors and Development*, 8, 65-77.
- Shiffrin, R. M (1988). Attention. In R. C. Atkinson, R. J. Herrnstein, G. Lindzey, & R. D. Luce (Eds.), *Steven's handbook of experimental psychology* (2<sup>nd</sup> ed., pp. 739-811). New York: Wiley.
- Shiffrin, R. M., & Dumais, S. T. (1981). The development of automatism. In J. R. Anderson (Ed.), *Cognitive skills and their acquisition* (pp.111-140). Hillsdale, NJ: Erlbaum
- Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. *Psychological Review*, 84, 127-190.
- Smith, M. C., & Magee, L. E. (1980). Tracing the time course of picture-word processing. *Journal of Experimental Psychology: General*, 109, 373-392.
- Spieker, S. (1985, April). *Infant discrimination and generalized recogniton of dynamic facial expressions*. Paper presented at the Biennial Meeting of the Society of Research in Child Development, Toront, Ontraio.
- Stanner, R. F., Byrd, D. M., & Gabriel, R. (1985). The time it takes to identify facial

- expressions: Effects of age, gender of subject, sex of sender, and type of expression. *Journal of Nonverbal Behavior*, 9, 201-213.
- Stenberg, G., Wiking, S., & Dahl, M. (1998). Judging words at face value: Interference in a word processing task reveals automatic processing of affective facial expressions. *Cognition and Emotion*, 12, 755-782.
- Stone, V. E., Nisenson, L., Eliassen, J. C., & Gazzaniga, M. S. (1996). Left hemisphere representations of emotional facial expressions. *Neuropsychologia* 34, 23-29.
- Strauss, E., & Moscovitch, M. (1981). Perception of facial expressions. *Brain and Language*, 13, 308-332.
- Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, 18, 643-662.
- Terzian, H. (1964). Behavioral and EEG effects of intracarotid sodium amytal injection. *Acta Neurochirurgia*, 12, 230-239.
- Tiller, D. K. (1988). *Structure in the affective lexicon*. Unpublished master's thesis, University of Oxford, Oxford, England.
- Tomkins, S. S. (1962). *Affect, imagery, consciousness. Vol. I. The positive affects*. New York: Springer.
- Tomkins, S. S. (1963). *Affect, imagery, consciousness. Vol. II. The negative affects*. New York: Springer.
- Tooby, J., & Cosmides, L. (1990). The past explains the present: emotional adaptations

- and the structure of ancestral environment. *Ethology and Sociobiology*, 11, 375-424.
- Treisman, A. (1988). Features and objects: The fourteenth Bartlett memorial lecture. *Quarterly Journal of Experimental Psychology*, 40, 201-237.
- Uleman, J. S. (1989). A framework for thinking intentionally about unintended thought. In J. S. Uleman & J. A. Bargh (Eds.), *Unintended thoughts* (pp. 425-449). New York: Guilford Press.
- Underwood, G. (1976). Semantic interference from unattended printed words. *British Journal of Psychology*, 67, 327-338.
- Walden, T. A., & Field, T. M. (1982). Discrimination of facial expressions by preschool children. *Child Development*, 53, 1312-1329.
- Watson, D., Clark, L. A., & Tellegen, A., (1988). Development and validation of brief measures of Positive and Negative Affect: The PANAS scales. *Journal of Personality and Social Psychology*, 54, 1063-1070.
- Weissman, D. H., & Banich, M. T. (2000). The cerebral hemispheres cooperate to perform complex but not simple tasks. *Neuropsychology*, 14, 41-59.
- White, M. (1995). Preattentive analysis of facial expressions of emotion. *Cognition and Emotion*, 9 (5), 439-460.
- Yoshizaki, K., & Tsuji, Y. (1998, February). *The benefits of interhemispheric integration on the Japanese Kana script matching tasks*. Poster session presented at the annual meeting of International Neuropsychological Society, Honolulu, Hawaii.

Young-Browne, G., Rosenfield, H. M., & Horowitz, F. D. (1977). Infant discrimination of facial expressions. *Child Development*, 48, 555-562.

Zajonc, R. B. (1985). Emotion and facial efference: A theory reclaimed. *Science*, 228, 15-21.